user manual

pco.edge family

pco.

Target Audience: This camera is designed for use by technicians, engineers, and scientists.

In case of any questions or comments, please contact us at PCO.

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The cover photo shows an exemplary PCO camera system.
The lens is sold separately.

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1. INTRODUCTION

Advantages of the pco.edge family

The pco.edge family is a breakthrough in scientific imaging cameras. It has the distinctive ability to simultaneously deliver extremely low noise, high frame rates, wide dynamic range, high quantum efficiency, high resolution and a large field of view - all in one image.

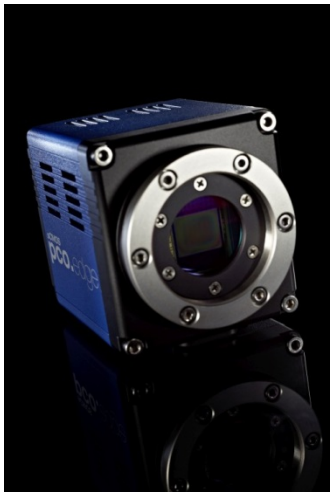
The camera's main features (model–specific)

- ***ultra low noise*** 0.8 electrons med (pco.edge (gold) 4.2)
- ***high resolution*** 5.5 megapixel (pco.edge 5.5)
- ***best dynamic range*** 36000:1 (pco.edge (gold) 4.2)
- ***high-speed*** 100 fps @ full resolution (pco.edge 4.2 & 5.5, Camera Link)
- ***high quantum efficiency*** up to 70% (pco.edge 4.2)
- ***deep cooling*** down to - 30 °C (pco.edge gold, water cooling)
- ***flexibility*** user selectable choice of shutter mode
- ***free of drift*** stabilized Peltier cooling in order to avoid any drift phenomena in image sequences

Areas of Application

- live cell microscopy
- single molecule detection
- localization microscopy
- lightsheet microscopy
- selective plane illumination microscopy
- SPIM
- structured illumination microscopy
- SIM
- TIRF microscopy / waveguides
- spinning disk confocal microscopy
- genome sequencing (2nd and 3rd gen)
- FRET
- FRAP
- lucky astronomy / imaging
- adaptive optics
- solar astronomy
- fluorescence spectroscopy
- bio- & chemiluminescence
- high content screening
- photovoltaic inspection
- x-ray tomography
- ophthalmology
- flow cytometry
- biochip reading
- machine vision
- spectral (hyperspectral) imaging
- laser induced breakdown-spectroscopy (LIBS)

1.1 DATA OVERVIEW



Overview – Available camera models

This table shows an overview over all available camera models.

Type	Inter-face	Shutter	Read Out Frequency	Line time (µs)	FPS	Sensor
pco.edge 3.1	USB 3.0	Rolling	105 MHz	24.93	50	mono & color
		Global	204 MHz	12.80	48	
		Global Reset	105 MHz	24.99	50	
pco.edge 4.2 LT	USB 3.0	Rolling	110 MHz	24.10	40	mono
		Global Reset	110 MHz	24.10	40	
pco.edge 4.2	USB 3.0	Rolling	110 MHz	24.10	40	mono
		Global Reset	110 MHz	24.10	40	
pco.edge 4.2	Camera Link	Rolling	95.3 MHz (slow scan)	27.60	35	mono
			272.3 MHz (fast scan)	9.65	100	
pco.edge 5.5	USB 3.0	Rolling	86 MHz	30.5	30	mono & color
		Global	160 MHz	16.40	28	
		Global Reset	86 MHz	30.51	30	
pco.edge 5.5	Camera Link	Rolling	95.3 MHz (slow scan)	27.52	33	mono & color
			286 MHz (fast scan)	9.17	100	
		Global	286 MHz	9.17	50	
		Global Reset	95.3 MHz (slow scan)	27.52	33	
			286 MHz (fast scan)	9.17	100	
pco.edge gold 4.2	USB 3.0	Rolling	110 MHz	24.10	40	mono
pco.edge gold 5.5	USB 3.0	Rolling	86 MHz	30.50	30	mono & color

2. SAFETY INSTRUCTIONS

Please read the safety instructions completely

Never operate the camera in humid or dusty environments or in places with high amounts of X-ray radiation. Humidity, dust or X-rays could damage the camera.

To avoid the risk of water condensation, protect the camera against extreme changes of ambient temperature. If condensation enters the camera, there is the risk of electric shock.

To prevent damage to the camera, the system must be kept stable and protected against strong jolts or vibrations. The socket at the bottom of the camera is to be used for mounting purposes only.

Electric shock warning – Never slide any items through slits or holes into the camera because of the risk of electric shock if the voltage parts inside are touched.

Each time the camera is used, check the power cable for any damage.

Never position the cable in a way that it could become a tripping hazard.

Do not force the lens onto the camera. To protect the lens connector thread from damage, use minimal force when attaching a lens to the camera.

If any of the following conditions apply, immediately switch off the camera, separate it from the power line and contact our customer support:

- If the power cable or the power plug seems to be worn or damaged.
- If liquids have penetrated the device.
- If, after thoroughly reviewing the instruction manual, the device is still not operating properly.
- If the camera has been dropped or the casing is damaged.

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3. SYSTEM COMPONENTS

The camera system includes the following parts.

Camera Head

F-mount optical connection (standard)
For standard F-mount / SLR lenses and adapters.

C-mount ring provided (see appendix **A2**)
For standard C-mount and microscopy connectors.

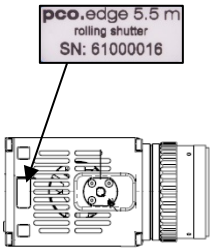
DC Power Jack (connect to power supply)

Input/Output 4x SMA connectors 2x input - 2x output

Interface (user selectable) Dual Camera Link full or USB 3.0

LED indicates camera status

Green continuous:	camera is booting	
Green blinking:	camera is ready for operation	
Yellow blinking:	recording on	
Red blinking:	error	



Serial Number Tag (on the bottom of the camera)

Mounting Thread

1/4-20 UNC mounting thread

Camera Link Grabber Card / USB 3.0 PCI Interface Card

PCI Express x4 Card (Camera Link ***full***) or
PCI Express x1 Card (2 x USB 3.0 connections)

A PCI Card with 4 x USB 3.0 connections is also available, contact PCO for further details. A PCIe x4 slot is necessary for this card.

Power Supply

Your system will be equipped with either a 24 V or a 12 V power supply, depending on the model you selected. (connector: Lemo FGG.0B)

Cable

CameraLink Cable (2x3m) or USB-A/USB-B cable (5m)

Digital Camera Tools (USB storage device content)

- CamWare: software for camera control & image acquisition
- Camera driver & tools
- Software development kit (SDK) & demo programs in C and C++

4. INSTALLATION

You will find all necessary files on the accompanying USB storage device. You may also download the newest versions of our software, camera driver and third party software drivers from the PCO website (www.pco.de).

Minimum system requirements:

- Clock speed > 2 GHz
- RAM > 4 GB
- Windows 7 or higher
- 1280 x 1024 pixel resolution display
- USB 3.0 or Camera Link

4.1 CAMERA DRIVER

There are two different camera interfaces available:

Camera Link (Frame Grabber)

When operating the camera with ***Camera Link Interface***: Please run the appropriate grabber driver installation with default settings.
For ***detailed installation instructions*** please see **A4** (microEnable IV grabber instruction).

USB 3.0

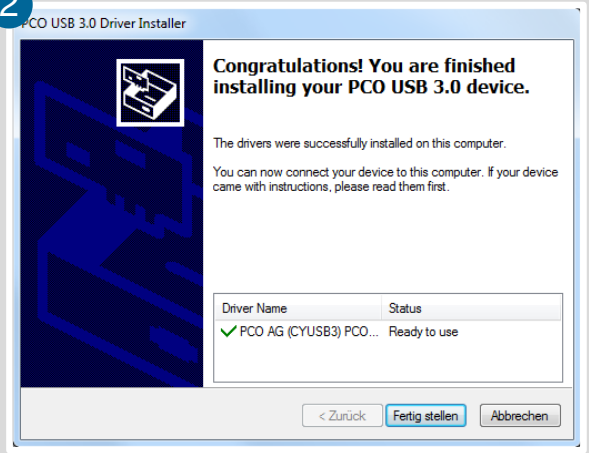
When ***USB 3.0*** is used as a camera interface, it is recommended to use the enclosed ***PCI Interface card***. For ***detailed installation instructions*** or further hardware recommendations, see **A5.**

Install PCO USB 3.0 Driver
For pco.edge USB 3.0 you always need to install the latest ***USB Driver version***. After these two screens 1 2 the driver is completely installed.

1

PCO USB 3.0 Driver Installer
Welcome to the PCO USB 3.0 Driver 64 Bit Installer!
This wizard will walk you through updating the drivers for your PCO USB 3.0 device.
Please read PCO's white paper about the USB 3.0 interface to find additional information (http://www.pco.de/knowledge-base/).
To continue, click Next.
< Zurück
Weiter >
Abbrechen

2


PCO USB 3.0 Driver Installer
Congratulations! You are finished installing your PCO USB 3.0 device.
The drivers were successfully installed on this computer.
You can now connect your device to this computer. If your device came with instructions, please read them first.
Driver Name
Status
PCO AG (CYUSB3) PCO...
Ready to use
< Zurück
Fertig stellen
Abbrechen

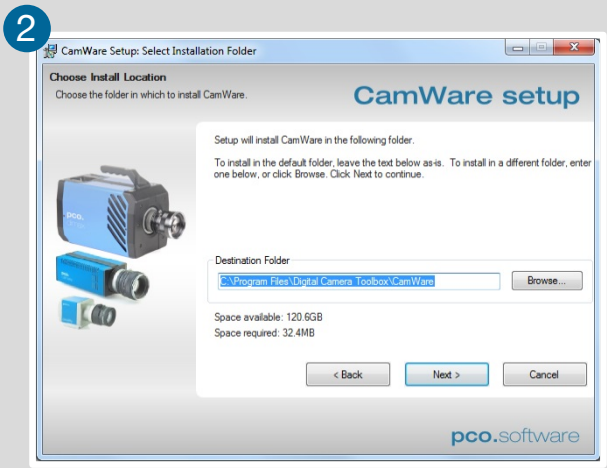
4.2 CAMWARE

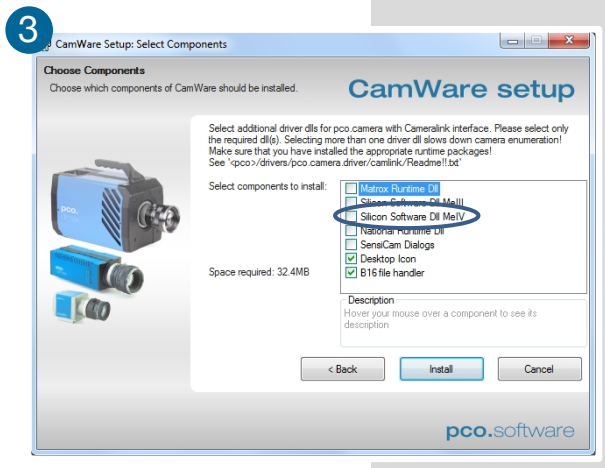
The CamWare Windows application software enables you to control every camera parameter or setting. Images can be displayed on a monitor and may be downloaded and stored. The USB storage device contains the installation files for the software for latest Windows operating systems in 32 & 64 bit.
After a successful installation, you will find the program file ***Digital Camera Toolbox*** in your program directory and a ***CamWare32/64 button*** on your desktop. Other helpful tools are also installed in the same directory.
To uninstall the CamWare program, please use the Software feature under Windows' System Control.

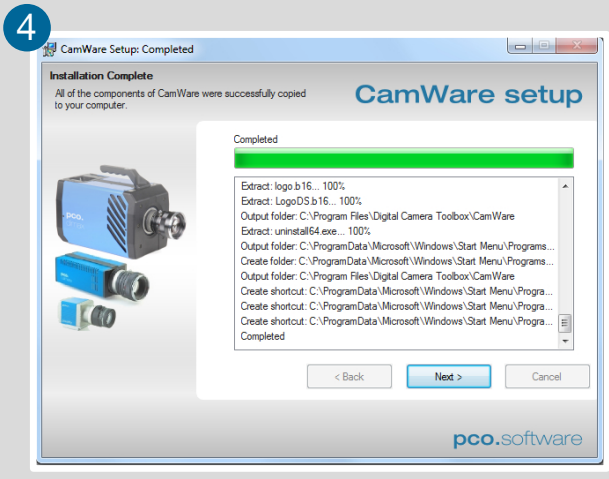
Please follow the installation wizard

1. Install CamWare as Admin to install to program folder, instead it will be installed only to user folder
2. Then choose install directory
3. Choose components: Select additional drivers for Camera Link Interface (Silicon Software Dll mE IV)
4. After the next two screens installation is complete

1
CamWare Setup V3.16.0000 - pco ag
Welcome to the CamWare installer!
This will install version 3.16.0000 (64bit).
CamWare setup
Welcome to the CamWare USER Setup Wizard
This wizard will guide you through the installation of CamWare.
It is recommended that you close all other applications before starting Setup.
To continue click Next. Installing as user.
This will install into user area and not in program files folder!!!
In case you like to install to program files folder, please install as administrator by clicking 'Install as admin'.
Install as admin
< Back
Next >
Cancel
pco.software


2
CamWare Setup: Select Installation Folder
Choose Install Location
Choose the folder in which to install CamWare.
CamWare setup
Setup will install CamWare in the following folder.
To install in the default folder, leave the text below as-is. To install in a different folder, enter one below, or click Browse. Click Next to continue.
Destination Folder
C:\Program Files\Digital Camera Toolbox\CamWare
Browse...
Space available: 120.6GB
Space required: 32.4MB
< Back
Next >
Cancel
pco.software


3
CamWare Setup: Select Components
Choose Components
Choose which components of CamWare should be installed.
CamWare setup
Select additional driver dlls for pco.camera with Cameralink interface. Please select only the required dll(s). Selecting more than one driver dll slows down camera enumeration!
Make sure that you have installed the appropriate runtime packages!
See "<pco>/drivers/pco.camera.driver/camlink/Readme!!.txt"
Select components to install:
Matrox Runtime Dll
Silicon Software Dll MeIV
National Runtime Dll
SensiCam Dialogs
Desktop Icon
B16 file handler
Space required: 32.4MB
Description
Hover your mouse over a component to see its description
< Back
Install
Cancel
pco.software



5. QUICK START

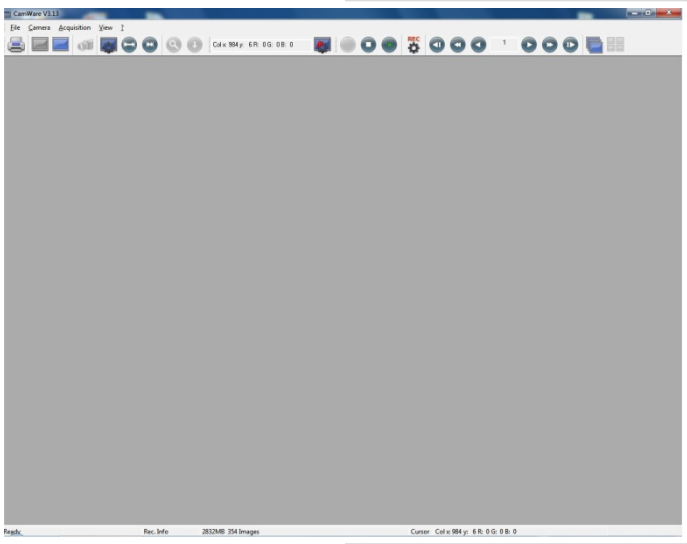
In order to get familiar with your new camera and software it might be helpful, if you first aim at an object that is easy to focus and that can be seen at standard light conditions.

5.1 PREPARATION

- ***Computer*** is turned on
- ***Installation*** is finished (see chapter **4)**
- ***An appropriate lens*** is attached (remove cap) or the camera is attached properly to the microscope, spectrograph or other scientific device
- ***Camera*** is connected to the PC (USB 3.0 or Camera Link)
- ***Camera*** is connected to the power supply and ready (green LED blinks)

5.2 START

Start ***CamWare*** and the ***graphical user interface*** will start up:

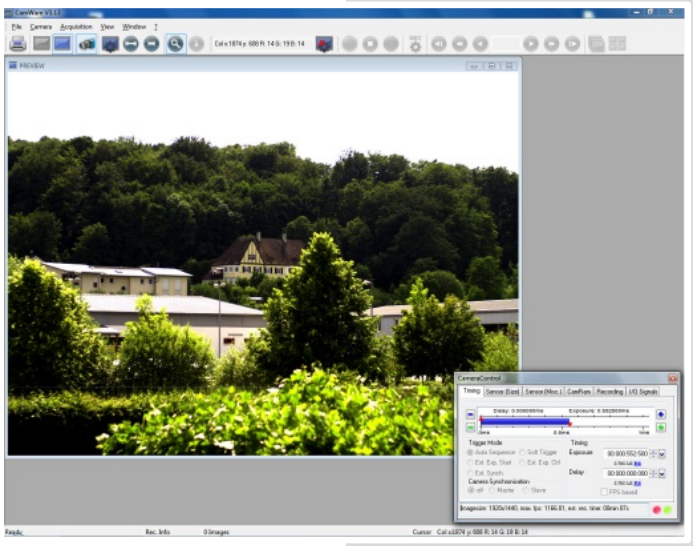


NOTE
Always install latest CamWare version to be able to use full function of your pco camera.

5.3 YOUR FIRST IMAGE

Please follow the instructions:

1. ***CamWare*** must be started
2. Open view window ***(b/w or color)***
3. Start ***live preview***
4. Apply ***auto range peak***
5. You may adjust ***exposure time***, ***aperture*** and ***focus***
6. Now you should clearly see the ***object*** in the window



During ***live preview*** mode, most settings are disabled.

If you need to change ***exposure*** time (e.g. the image is still either too dark or too bright), please go to chapter **6.1**

If you want to record and save images, please see chapter **6** and chapter **7** for detailed information.

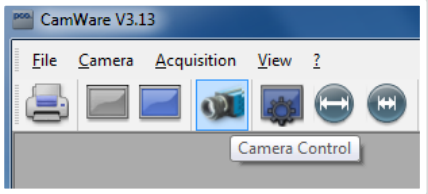
(Screenshot shows color camera)

NOTE
Live preview: useful for fast and easy camera adjustment and focusing. This command disables the Camera Control window if it is opened (except exposure time setting).

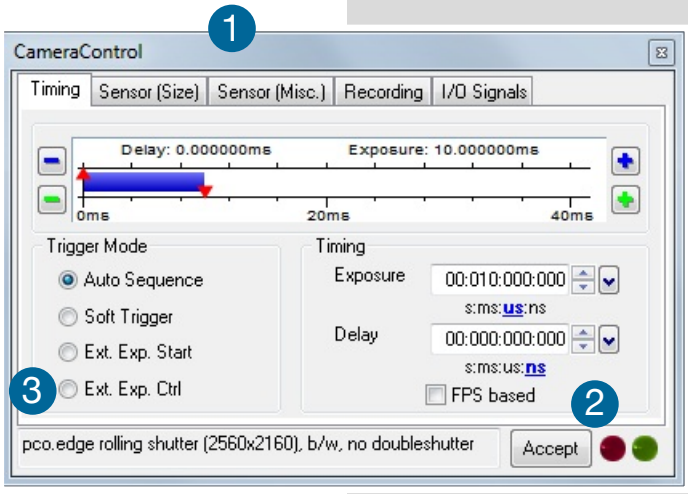
6. CAMERA CONTROL

The ***Camera Control*** window in CamWare is the main interface for all camera settings. For further CamWare features please see chapter **7.**

6.1 THE CAMERA CONTROL WINDOW



The camera control window can be opened by selecting the proper command in the ***Camera***-Menu or by the corresponding button in the toolbar.



The camera control dialog always adapts to the camera type connected. For pco.edge the camera control settings are spread over five ***property sheets*** 1 , which are explained on the next pages.

Changes to the camera control sheets must be completed by pressing the ***Accept button*** 2.

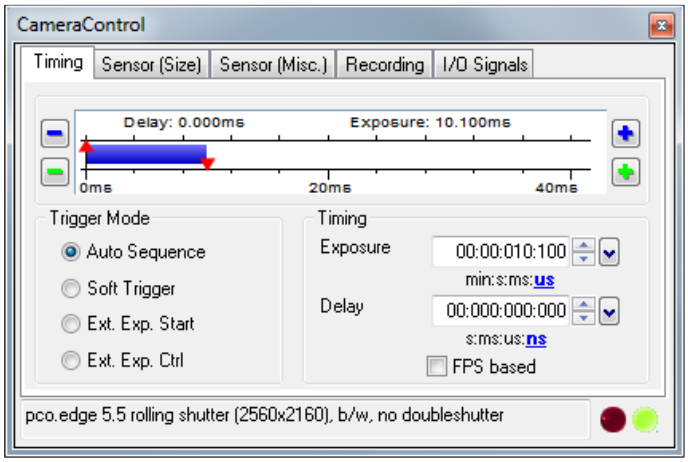
The ***information field*** 3 shows various information about the camera. Click into the info field to change the displayed views.

There are three different views of the ***information field*** 3

pco.edge 5.5 rolling shutter (2560x2160), b/w, no doubleshutter	Camera type
El. Temp.: 33 °C, Sensor Temp.: 5 °C, Power Temp. 34 °C	Actual temperatures
Imagesize: 2560x2160, max. fps: 99.90	Image size and frame rate

NOTE
If the ***Accept*** button is not pressed, these changes will be ignored and lost. If the changes are within the allowed condition limits of the camera, the green lamp will be highlighted. The camera control dialog automatically adjusts settings in case they are out of limits.

6.2 THE TIMING TAB



Introduction to timing

An important parameter for a camera is the frame rate. The upper limit of the frame rate is defined by exposure and readout time.

The figure below shows the timing scheme. Exposure and readout are done simultaneously, this means while image ***n*** is readout from the sensor, image ***n+1*** is already integrated within the sensor's pixel elements.

Figure 1 shows, that in case of short exposure times, the readout is the limiting factor. The second figure 2 shows that for long exposure times the exposure time plus delay (t_{delay}) is the limiting factor.

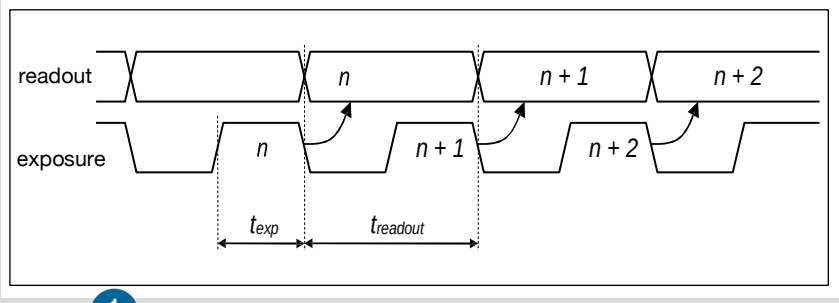


Figure 1: Image timing for short exposure times

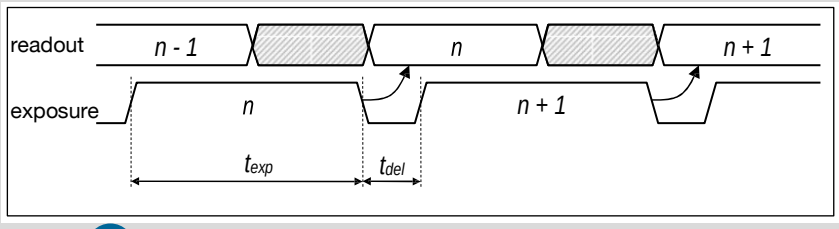
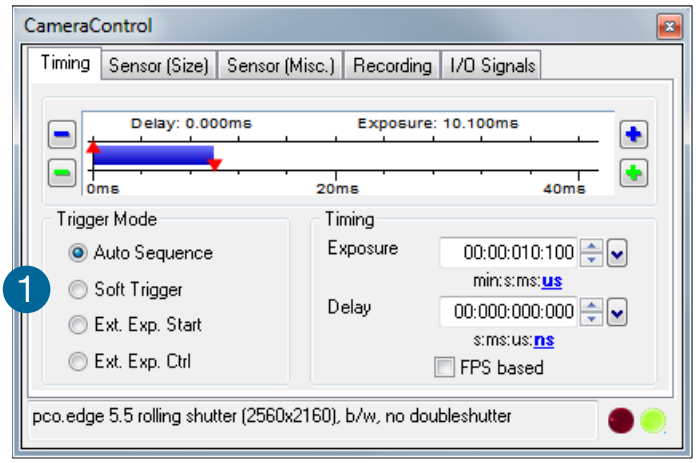


Figure 2: Image timing for long exposure times

If a lower frame rate is desired, this can be achieved by inserting additional delay times. These rules also apply in external trigger mode, i.e. this defines when the next trigger can be applied or recognized.



Trigger Mode 1

In this context trigger means exposure trigger, i.e. the trigger signal controls the exposure of a single image (light integration time).

Auto Sequence: The camera will optimize the image recording to achieve the best possible frame rate.
In the auto sequence exposure control mode, the camera determines the fastest possible frame rate depending on the adjusted exposure time and the required readout time.

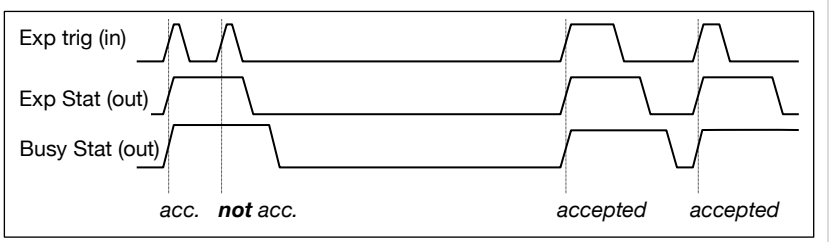
After a start command is given, the sequential recording is started until a stop command is given.

NOTE
If the trigger rate of the external signal is quite near the maximum possible frame rate (difference < 1/1000), it will be random, whether or not a trigger is accepted!

Soft Trigger: Single images can be recorded with this CamWare command. The single image can be acquired by pressing the ***Single Trigger*** button. This button appears after pressing the ***Start Record*** button (see **7.2**). Other signals cannot influence this operating mode. For test purposes only.

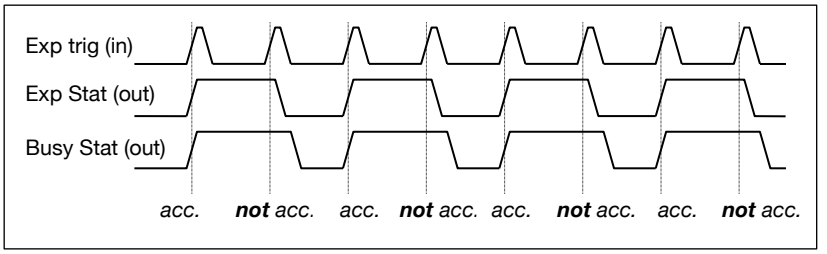
In the ***External Exposure Start*** exposure control mode, single image recording is started by the falling or rising edge of the voltage signal at the BNC input #1(see **6.6**). The frame rate cannot be set, as the frame rate is defined by the frequency of the external signal. However the predefined exposure time and ROI settings affect the maximum possible frame rate.

The ***Busy Status*** signal at BNC #3 (BNC explanation see **6.6**) will indicate if a new trigger is accepted.



The maximum achievable frame rate in external trigger mode is negligibly less (about 0.1%) than operating the camera in ***Auto Sequence*** mode.

If the trigger rate of the external signal is higher than the maximum possible frame rate, every second trigger pulse is ignored. Therefore the actual frame rate drops to half of the external trigger rate. If the trigger rate is increased further, then only every third, every fourth etc. trigger edge will be accepted.

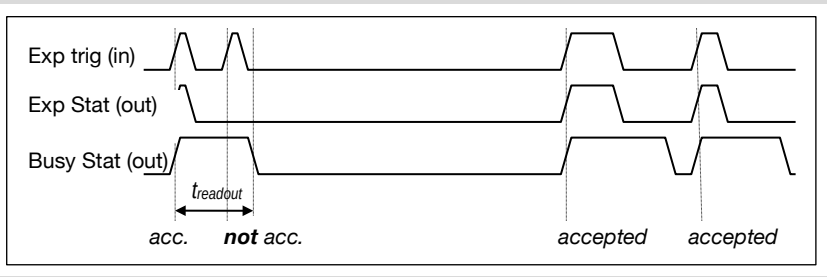


In order to avoid trade-offs at maximum frame rate use either the ***Busy Status*** signal or make sure that the external trigger rate follows this condition: 0.999 x External Trigger Rate ≤ fmax.

External Exp. Control An external signal applied at BNC #1 (see **6.6**), controls the ***start*** and the ***duration*** of the exposure.

A new exposure is started by the falling or rising edge of the voltage signal at the BNC input. The exposure is finished when the opposite edge is detected. Thus in this mode, the start as well as the length of the exposure time can be controlled.

No further settings can be made, as the image timing is completely controlled by the external trigger signal.



Be aware, that the externally controlled exposure time is limited. The integration will be stopped automatically if the maximum exposure time is achieved.

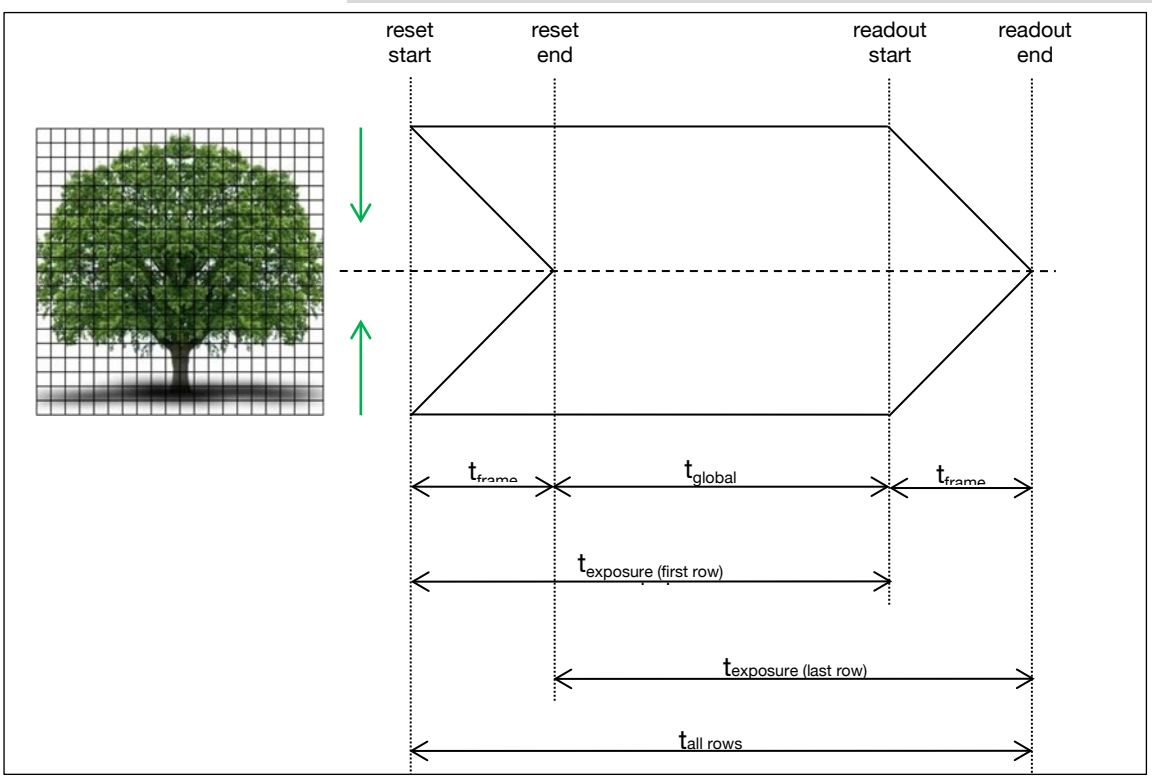
The Busy Status signal at BNC #3 (see **6.6**) indicates if a new trigger is accepted.

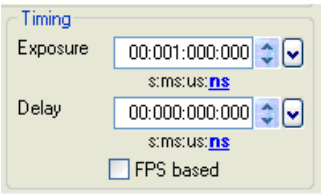
Camera	Interface	Shutter Mode	Max.exposure time
pco.edge 3.1	USB 3.0	Rolling	2 s
		Global	100 ms
		Global Reset	2 s
pco.edge	USB 3.0	Rolling	10 s
		Global Reset	2s
pco.edge 4.2	CameraLink	Rolling	10 s
pco.edge 4.2	USB 3.0	Rolling	20 s
pco.edge gold	USB 3.0	Rolling	60 s
pco.edge 5.5	Camera Link	Global	100 ms
		Rolling & Global Reset	2 s
pco.edge 5.5	USB 3.0	Rolling	2 s
pco.edge gold	USB 3.0	Rolling	10 s

6.2.1. ROLLING SHUTTER

In ***Rolling Shutter*** mode the pixel reset and exposure start is carried out row by row. Each row has the same exposure time, but a different start and end of exposure. The pco.edge image sensor consists of two discrete halves, which are exposed and read out simultaneously, i.e. from the outside to the center by default. Within one row, the exposure starts simultaneously for all pixels. Available ***RS*** readout modes see **7.4**.

General Timing Diagram



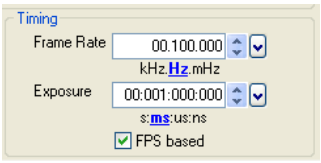


The exposure time of each row starts with the corresponding reset of the row. Then after a predefined time, the exposure is stopped. The light induced accumulated charge carriers of the pixels in a row are recorded into memory in a low noise (readout) mode. This results in the total image appearing in memory corresponding to the row readout.

Timing

The exposure and delay time can be adjusted in steps of one line time (see p.**6**).

Camera (RS only)	Interface	Exposure time	Delay time
pco.edge 3.1	USB 3.0	500 µs … 2 s	0 … 1 s
pco.edge 4.2 LT	USB 3.0	100 µs … 10 s	
pco.edge 4.2	Camera Link	100 µs … 10 s	
pco.edge 4.2	USB 3.0	100 µs … 20 s	
pco.edge gold 4.2	USB 3.0	100 µs ... 60 s	
pco.edge 5.5	CL & USB 3.0	500 µs … 2 s	
pco.edge gold 5.5	USB 3.0	500 µs ... 10 s	



FPS based (only ***Camera Link*** interface)
The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.
Only for ***Auto Sequence*** trigger mode ***and*** only available with ***Camera Link*** Interface

First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.

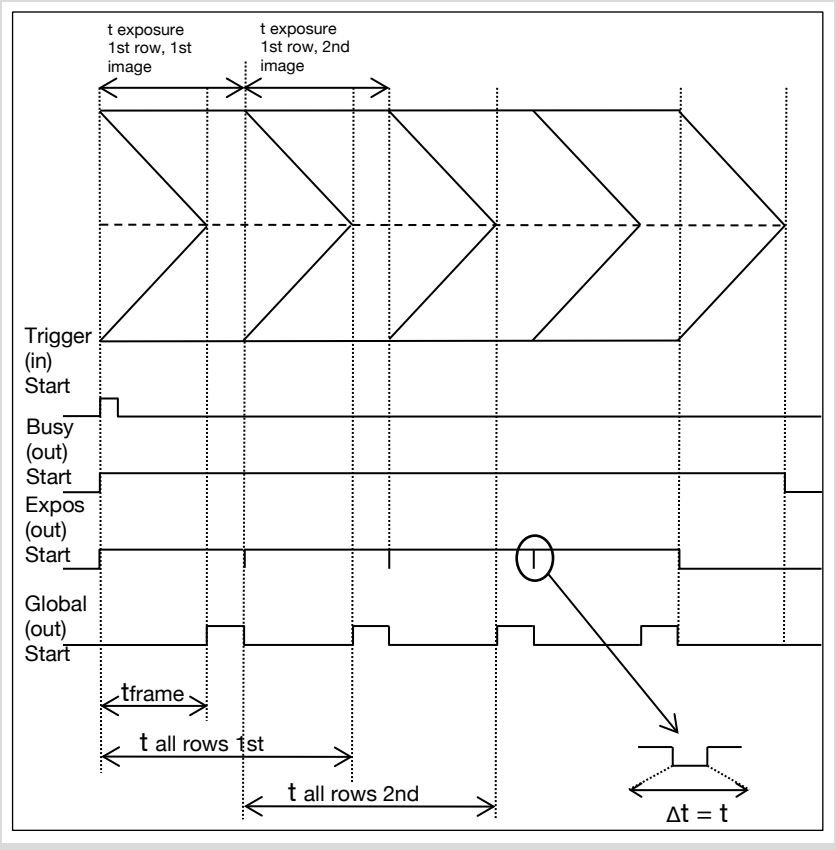
The frame rate can be adjusted in steps of 1 mHz (Rolling Shutter).
If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (RS only)	Interface	Frame rate (FPS Based)	Exposure time
pco.edge 4.2 (@ full resol.)	Camera Link	0.1…35 Hz @ 95.3 MHz 0.1…100 Hz @ 272.3 MHz	100 µs…10 s
pco.edge 5.5 (@ full resol.)	Camera Link	0.5…33.3 Hz @ 95.3 MHz 0.5…100 Hz @ 286 MHz	500 µs…2 s

NOTE
Δ t = t : 1 line time
(See p.**6**)

Exposure time > Sensor frame readout time (Auto Sequence)

In case the required exposure time is longer than the frame readout time, the image sensor is completely exposed to light for some time (t_{global}). In case of a triggered flash illumination, this would be the best moment to illuminate the image sensor.



The hardware signal for the time t_{global} is available on ***connector #4*** (Global out see **6.6**).

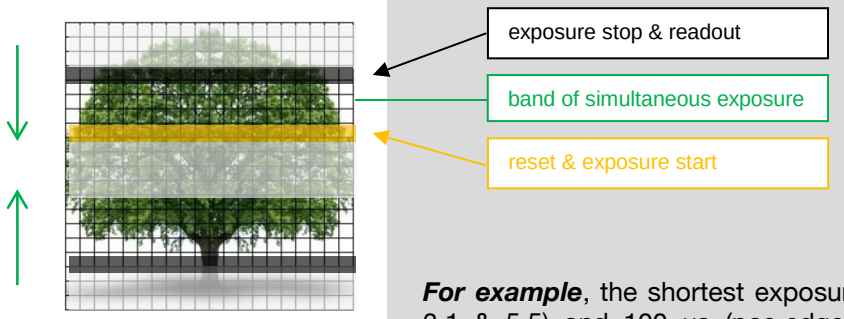
Obviously, if during exposure and readout, parts of the viewed image are moving horizontally, this would result in image distortion. This is why the global shutter mode may be a prerequisite for some applications.

However, most dynamic events can be captured in 1 ms, which is a common integration time with SLR cameras set at 1/1000 exposure. The time shift from one row to another is only about 10 µs (fast scan). The resulting maximum readout time of 10 ms (at full resolution) seems to be sufficient for a broad spectrum of dynamic events.

The 10 ms is also faster than the image shift process of most frame transfer ***emCCD*** image sensors previously used for low light applications. If this does not influence the image recording and processing, then rolling shutter mode will not affect it either.

Exposure time < Sensor frame readout time (Auto Sequence)

In case the required exposure time is shorter than the frame readout time, the image is composed of two exposure bands moving from the outside to the center of the sensor.



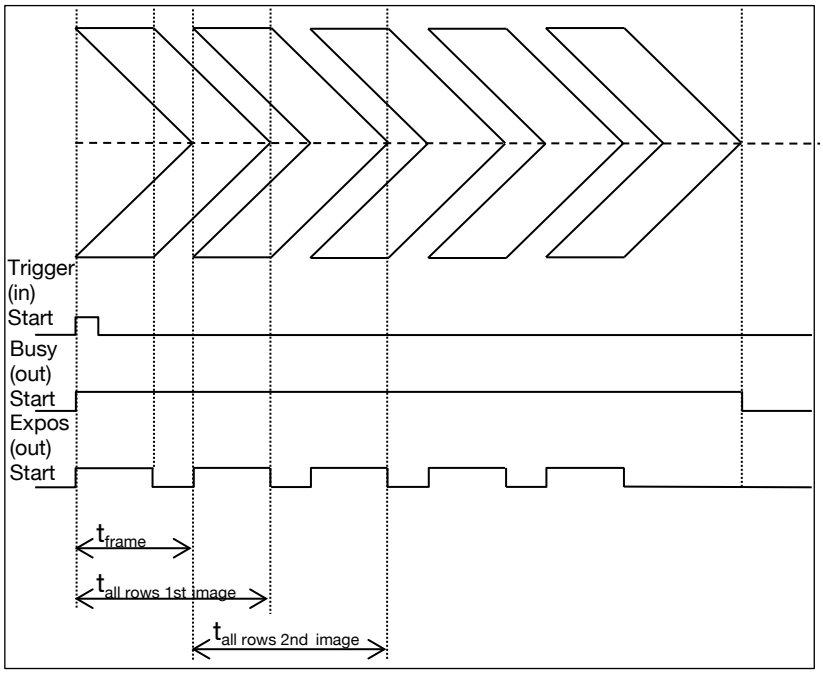
For example, the shortest exposure time in ***RS*** is 500 µs (pco.edge 3.1 & 5.5) and 100 µs (pco.edge 4.2). The band of simultaneous exposure is in this case (smallest possible height) at full resolution:

e.g. pco.edge 4.2: 100 µs / 24.93 µs (line time) = 4 → number of simultaneous rows = 8 (Rolling Shutter mode A-D see **7.4**)

Previous comments on image distortion (also known as Rolling Shutter Effect) apply here as well.

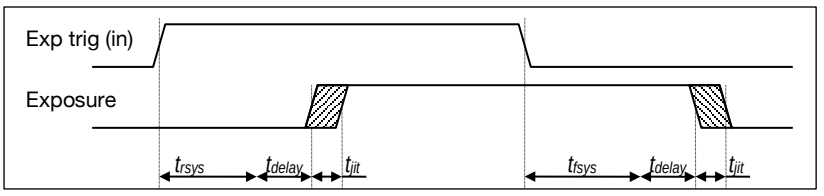
Graph on next page.

Auto Sequence graph



Details for External Exp. Start and External Exp. Ctrl

The detailed timing for external trigger includes system delay times, an adjustable additional delay time, and the jitter.



Camera (RS only)	Interface	System clock	t_{svs} (t_{rsys}/ t_{fsys})*	t_{jit} (jitter)	t_{delav} (delay)
pco.edge 3.1	USB 3.0	100 MHz	50 ns	≤1 line time (see p.**6**)	0 … 1s
pco.edge 4.2	Camera Link	72 MHz	70 ns		
pco.edge 4.2 / 4.2 LT / gold 4.2	USB 3.0	100 MHz	50 ns		
pco.edge 5.5 / gold 5.5	USB 3.0	100 MHz	50 ns		
pco.edge 5.5	Camera Link	72 MHz	70 s		

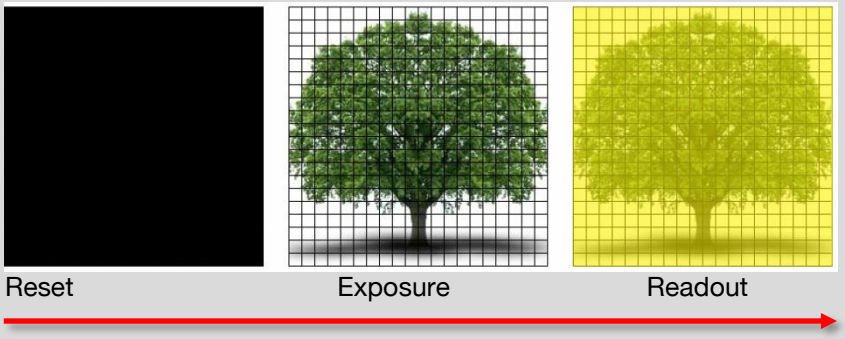
* t_{rsys}/ t_{fsys} = t rising edge / t falling edge
For optimized synchronization (minimized jitter time) use the falling edge of the line signal at the status output (see **6.6**).

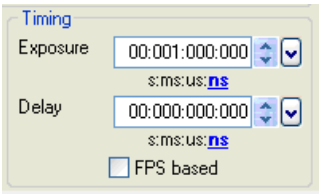
NOTE
The jitter t_{jit} can be a maximum of one row/line time.

6.2.2. GLOBAL SHUTTER

NOTE
Global Shutter is only available for pco.edge 3.1 and 5.5 Camera Link & USB cameras.

First, all pixels are globally reset and these reset values are shifted into so-called diffusion nodes. From there, they are non-destructively read out into memory as reset dark images. The exposure starts after transfer of the reset dark image to the diffusion nodes, where they are stored on the chip. The exposure is stopped by global charge transfer to the diffusion nodes. Then, the exposure image is read out to the memory, where the former reset dark image is subtracted to perform an external correlated double sampling, which reduces the noise. Since two images have to be read out to receive one resulting image, the sCMOS image sensor's ***Global Shutter*** mode has only half of the frame rate of the ***Rolling Shutter*** mode.

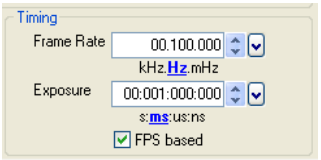




Timing

The exposure and delay time can be adjusted in steps of one line time (see page **6**).

Camera (GS only)	Interface	Exposure time	Delay time
pco.edge 3.1	USB 3.0	20 µs … 100 ms	0 µs … 1 s
pco.edge 5.5	Camera Link	10 µs … 100 ms	
pco.edge 5.5	USB 3.0	30 µs … 100 ms	



FPS based (only edge 5.5 ***Camera Link***)
The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.

Only for ***Auto Sequence*** trigger mode ***and*** only available with ***Camera Link*** Interface.

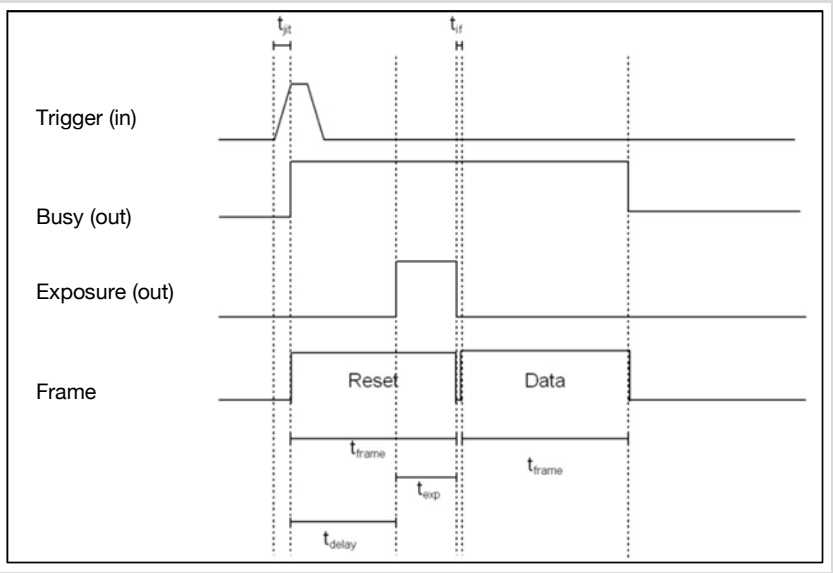
First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$. Minimum frame rate is 1 / max. exposure time.

The frame rate can be adjusted in steps of 1 MHz (Global Shutter).
If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (GS only)	Interface	Frame rate (FPS Based)	Exposure time
pco.edge 5.5	Camera Link	10 … 50 Hz @ 286 MHz	10 µs … 100 ms

External Exposure Start

(Auto Sequence respectively)



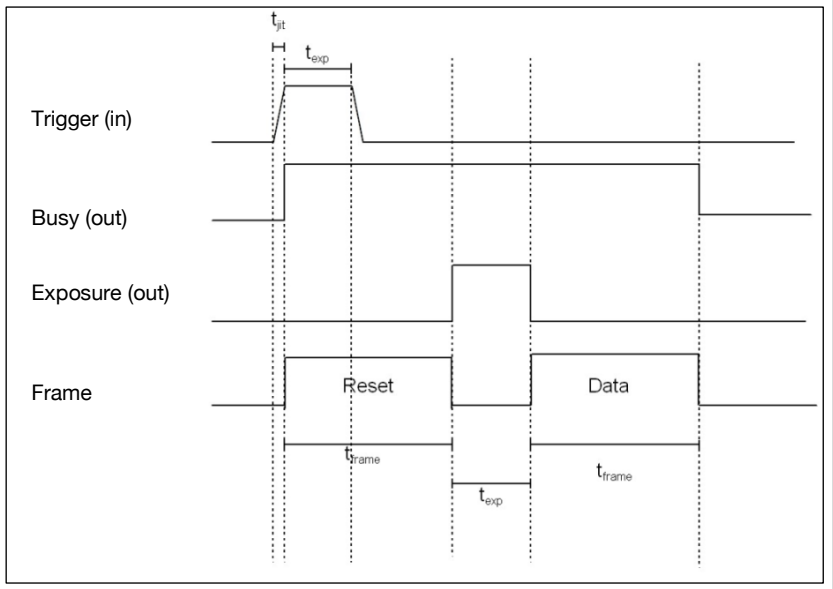
	# of lines
t_{iit}	line time[1]
t_{frame}	ROI (y) * line time[1]
t_{exp}	Programmable: 1 line time[1] … 100 ms
t_{delay} (system)	(t_{frame} – t_{exp})
t_{if}	line time[1]

[1]line time → see p.**6**

The listed parameters can be output via SDK function ***Get Image Timing*** dependent on the selected ROI.

NOTE
If $t_{exp} < t_{frame}$ system delay (t_{delay}) is added before exposure starts.

External Exposure Control



	# of lines
t_{iit}	line time[1]
t_{frame}	ROI (y) * line time[1]
t_{exp}	Counted line time[1]

[1]line time → see p.**6**

In ***External Exposure Control*** trigger mode the external signal controls start of image acquisition and duration of the exposure.

First, all pixels are globally reset and these reset values are shifted into so-called diffusion nodes. From there, they are non-destructively read out into memory as reset dark images.

In this mode, the exposure starts always after the readout of the dark image is completed. The length of the exposure has been detected by the sensor from the trigger input. The exposure is stopped by global charge transfer to the diffusion nodes after the respective time.

Then, the exposure image is read out to the memory, where the former reset dark image is subtracted to perform an external correlated double sampling, which reduces the noise.

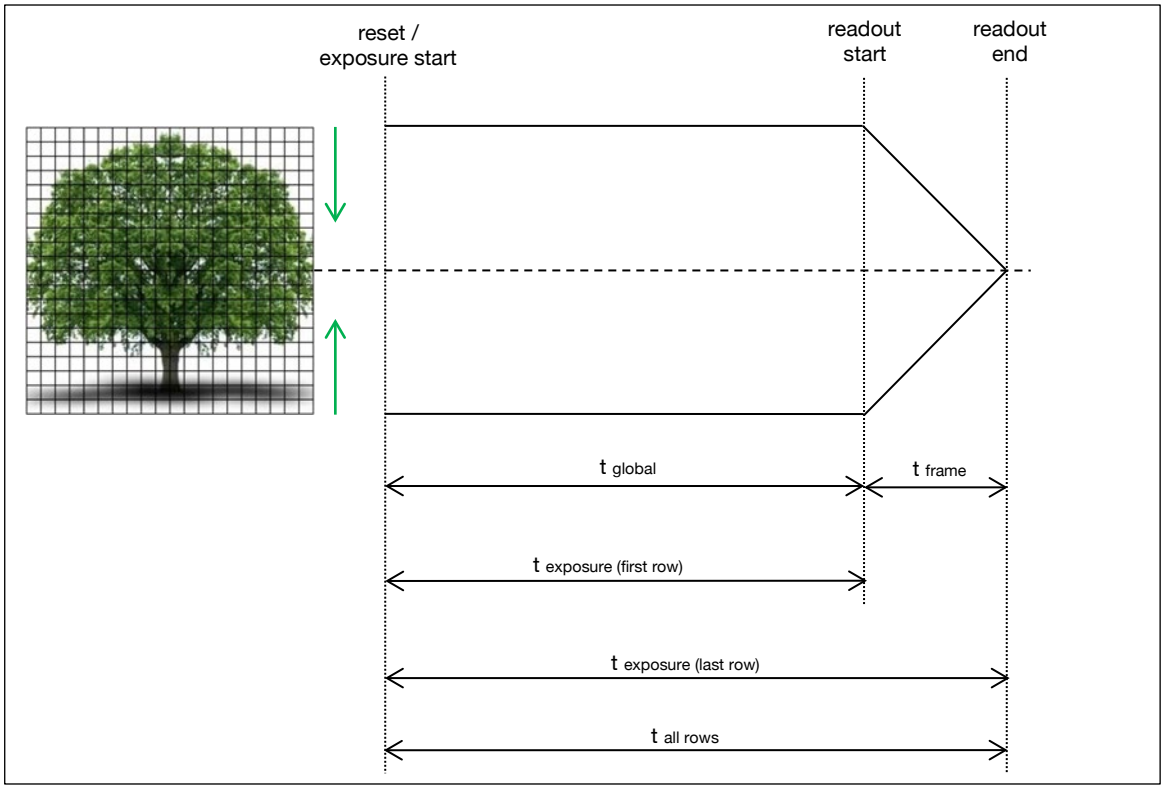
Since two images have to be read out to receive one resulting image and the exposure cannot start during readout time of the dark image, this specific ***Global Shutter*** mode provides less than half of the frame rate of the ***Rolling Shutter*** mode.

6.2.3. GLOBAL RESET

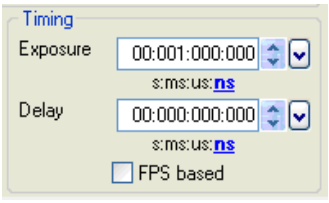
NOTE
Global Reset is available for pco.edge 5.5 CL and for all edge USB 3.0 cameras (excluding edge gold).

All pixels are globally reset and the exposure starts for all rows at the same time. The exposure stop is carried out row by row; therefore the duration of the exposure is not the same for all pixels. The rolling readout improves the image quality, but due to the difference in exposure time, a flash illumination is recommended. The readout (exposure stop) is done from the outside to the center.

General Timing Diagram



The exposure time of all rows starts simultaneously. The exposure time of the first row stops after the predefined time, the following rows are read out from the outside to the center row by row. Please note that this leads to a different duration of exposure time for all rows.

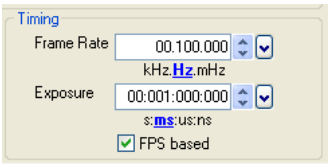


Timing

The exposure and delay time can be adjusted in steps of one line time (see p.**6**).

Camera (GR)	Interface	Exposure time	Delay time
pco.edge 3.1	USB 3.0	30 µs – 2 s	0 µs … 1 s
pco.edge 4.2 / pco.edge 4.2 LT			
pco.edge 5.5 /			
pco.edge 5.5	Camera Link	10 µs – 2 s	

pco.edge 4.2 (***Camera Link*** Interface) and pco.edge gold 4.2 & 5.5: Global Reset is ***not available***.



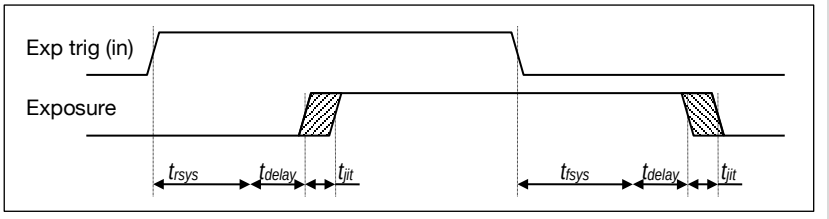
FPS based (only edge 5.5 ***Camera Link***)
The camera will optimize the image recording to achieve the selected frame rate with chosen exposure time as close as possible.
Only for ***Auto Sequence trigger*** mode ***and*** only available with **Camera Link** Interface.

First the frame rate is set. If the time required for readout of the image is longer than 1 / frame rate, then the frame rate will be reduced to 1 / $t_{readout}$.
The frame rate can be adjusted in steps of ***1 mHz*** (Global Reset).
If the selected exposure time would require a lower frame rate, the exposure time is cut to the maximum possible time at that frame rate.

Camera (GR only)	Interface	Frame rate (FPS Based)	Exposure time
pco.edge 5.5	Camera Link	1…33.3 Hz @ 95.3 MHz	10 µs…2 s
		1…100 Hz @ 286 MHz	

Details for External Exp. Start and External Exp. Ctrl

The detailed timing for external trigger includes system delay times, an adjustable additional delay time and the jitter.

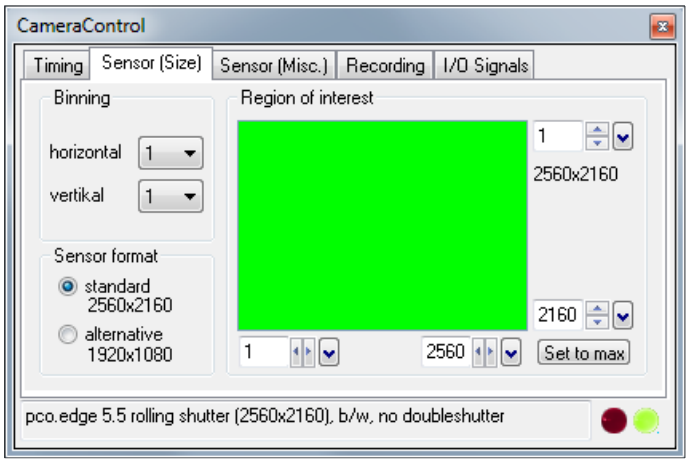


Camera (GR only)	Interface	t_{svs} (t_{rsys}/t_{fsys})	t_{jit} (jitter)	t_{delay} (delay)
pco.edge 3.1	USB 3.0	50 ns	≤1 line time[1]	0 µs …1 s
pco.edge 4.2 LT				
pco.edge 4.2				
pco.edge 5.5	Camera Link	70 ns		
pco.edge 5.5	USB 3.0	50ns		

[1]line time → see p.**6**

For optimized synchronization (minimized jitter time) use the falling edge of the line signal at the status output (see **6.6**).

6.3 THE SENSOR (SIZE) TAB



Binning 1

Binning combines neighboring pixels (in either the horizontal and vertical direction) to form super pixels. It increases the signal to noise ratio (SNR), reduces the readout noise of the resulting pixels and decreases the spatial resolution of the total image, which is recorded. For further information see **A6**.

Available Binning Modes:
H1xV1, H1xV2, H1xV4, H2xV1, H2xV2, H2xV4, H4xV1, H4xV2, H4xV4.

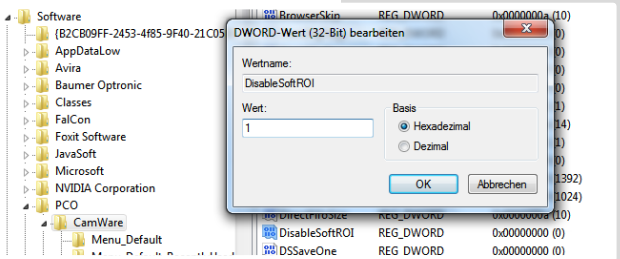
NOTE
Software based ROI (Soft-ROI) is enabled within CamWare by default (not available for USB 3.0 versions). Due to this functionality, the resolution of pco.edge cameras with **Camera Link interface** can be adjusted in steps of 1 – 4 pixels. Since the readout architecture of these cameras is not able to address single pixels, this downsizing is done by software. If you work with Device Adapters (µManager, Labview, etc.) or with our SDK, the Soft-ROI is disabled by default. For further information, please see the SDK description.

Region of Interest 2

The ROI (Region of Interest) selects only a part of the sensor to be read out.
Vertical ROI: In order to speed up the frame rate and to reduce the amount of image data, the selected ROI needs to be placed symmetrical to the horizontal center line.
Horizontal ROI: In order to reduce the amount of image data a horizontal ROI can be set. Please be aware, that changes in horizontal direction will not increase the frame rate. The decreased image size you see within CamWare is a combination of reduced sensor resolution and software downsizing (Soft-ROI).

Camera	Interface	ROI, horizontal increments	ROI, vertical increments	Min. ROI	Vert. symm. ROI
pco.edge 3.1	USB 3.0	4	1	64x16	no
pco.edge 4.2	Camera Link	1	1	40x8	no
pco.edge 4.2 / 4.2LT/gold 4.2	USB 3.0	4	1	64x16	no
pco.edge 5.5	Camera Link	4	1	160x8	no
pco.edge 5.5 / gold 5.5	USB 3.0	4	1	64x16	no

Controlling the Soft-ROI Option (only Camera Link version)



Under ***HKey-Current-User/Software/PCO/Camware*** create a DWORD value with the name ***DisableSoftROI***. Set this value to 1 in order to disable Soft-ROI. Remove or set this value to ***0*** in order to enable Soft-ROI by default. Keep in mind that unsymmetrical ROI decreases FPS. Table below shows values for Soft-ROI disabled.

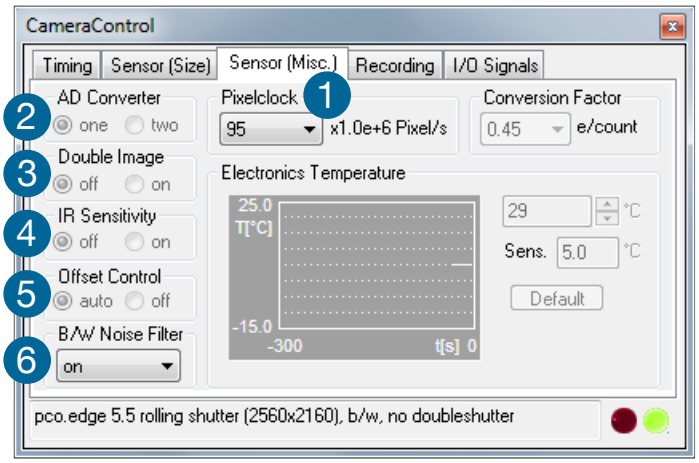
pco.edge 4.2	Camera Link	20	1	40x8	yes
pco.edge 5.5	Camera Link	160	1	160x16	yes

Sensor Format 3

Camera	Interface	Preselected Sensor Format
pco.edge 3.1	USB 3.0	2048 x 1536
pco.edge 4.2	Camera Link	2048 x 2048
pco.edge 4.2 / 4.2LT gold 4.2	USB 3.0	2048 x 2048
pco.edge 5.5	Camera Link	2560 x 2160 1920 x 1080
pco.edge 5.5 / gold 5.5	USB 3.0	2560 x 2160

CamWare will show the actual frame rate, corresponding to the selected image size, in the information box. Imagesize: 2560x2160, max. fps: 33.64

6.4 THE SENSOR (MISC.) TAB



Pixelclock 1

The pixel clock sets the clock frequency and therefore the image sensor readout speed.
(See overview table on page **6** for available readout frequencies.)

A/D Converter 2

(not available for pco.edge)

Double Image 3

This feature is widely used for particle image velocimetry (PIV) measurements, but not available for the standard pco.edge cameras.

IR Sensitivity 4

Feature is not applicable for pco.edge.

Offset Control 5

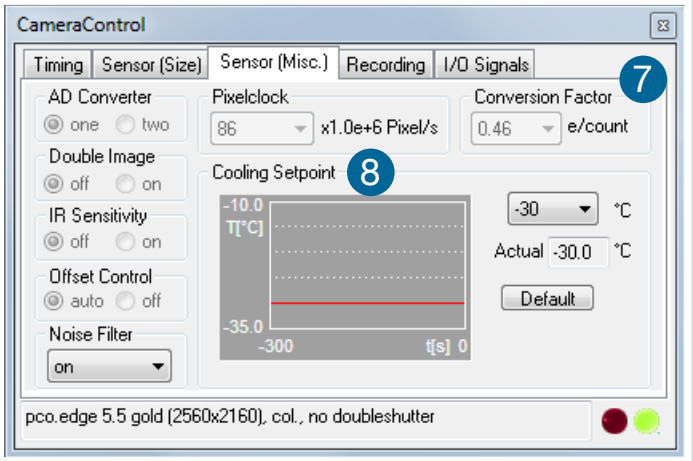
Offset control is done automatically for optimal results.

B/W Noise Filter 6

In addition to the integrated static defect pixel list processing a dynamic noise filter can be activated here in order to remove so-called ***blinkers and high noise pixels***. If you encounter unexpected aliasing effects, turn this filter off.

Conversion Factor 7

The conversion factor defines how many charge carriers (electrons), which have been generated by light in the image sensor in each pixel, are necessary to generate one count (one intensity level) in the digital image. Therefore, the conversion factor describes the gain that is applied to the signal before it is converted into a digital value. The conversion is optimized for the pco.edge @ 0.46 e^-/count.



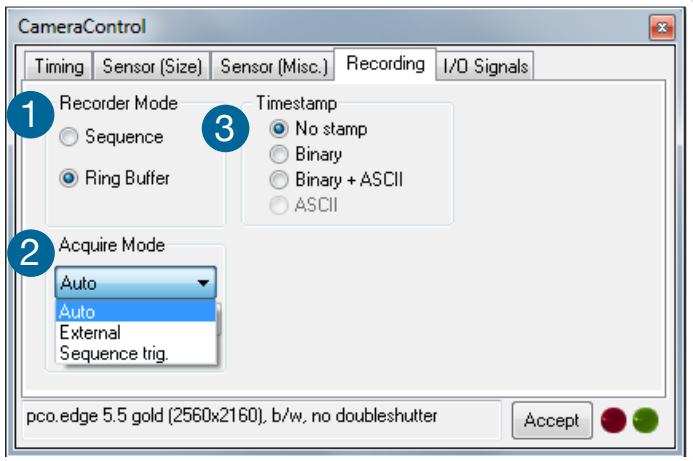
Cooling Setpoint 8

If a ***pco.edge gold camera*** is connected, a drop-down menu with selectable sensor temperatures will appear.

Display of sensor temperature: A peltier cooling unit is used to keep the sensor's dark current to an acceptable minimum and in order to allow for a continuous operation free of any drift phenomena in image sequences. Either an internal fan or an external water cooling system assures proper heat transfer from the peltier element to regulate the temperature of the cameras.

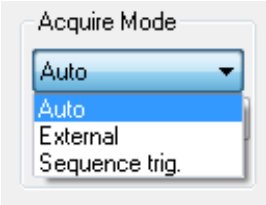
Camera	Interface	Sensor Temperature
pco.edge 3.1	USB 3.0	5 °C
pco.edge 4.2 LT	USB 3.0	10 °C
pco.edge 4.2/5.5	Camera Link	5 °C
pco.edge 4.2/5.5	USB 3.0	0 °C
pco.edge gold 4.2 pco.edge gold 5.5	USB 3.0	- 15 °C - 30 °C (water cooling only)

6.5 THE RECORDING TAB



Recorder Mode 1

CamWare will use free RAM space on your computer. The recorded images will be temporally saved as 16bit multi TIFF. In ***Sequence*** mode the recording stops when RAM space is full. In ***Ring Buffer*** mode the camera will stop only by a stop command, hence overwriting previous images. For longer recording periods an appropriate RAID system is necessary, see also the **Direct Record to File** option on **p. 38**.

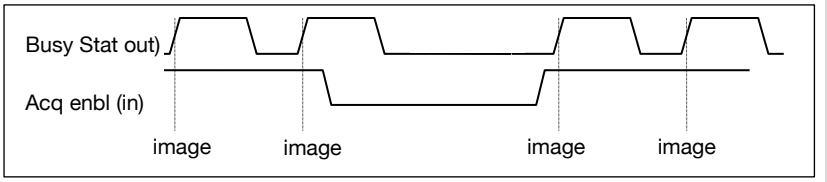


Acquire Mode 2

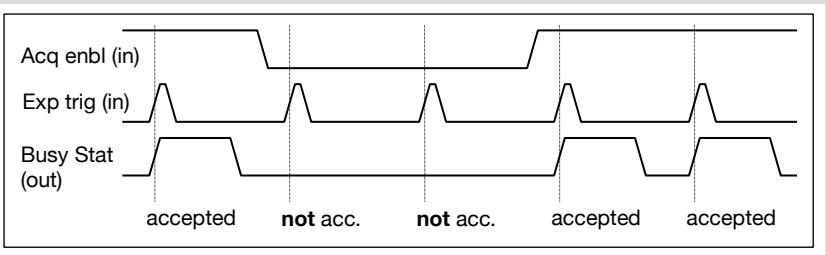
The acquire mode gives you the ability to enable or disable the recording by an external signal. If set to ***Auto*** all images are accepted and all images taken are saved. A signal at the ***acq enbl input*** (see chapter **6.6**) is ignored for this function. Operation of the acquire mode depends on the ***selected trigger mode***.

If set to ***External***, the camera will only record images if the external signal enables recording.

Trigger mode Auto Sequence: This sensor timing scheme is paused by the signal at the ***acq enbl*** input. The ***acq enbl*** input is sampled at the beginning of the image generation, which can be seen at the rising edge of the busy stat output. If the ***acq enbl*** input is high (low, when inverted) when an image is acquired, it causes an idle state until the ***acq enbl*** input is low (high, when inverted).

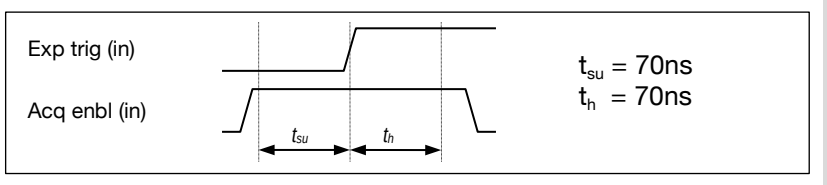


In ***trigger mode External Exp. Start***, the ***acq enbl*** input works like a gate for the trigger signal. A trigger edge (rising, falling when ***exp trig*** is inverted) is accepted only when the ***acq enbl*** signal is high (low, when inverted).

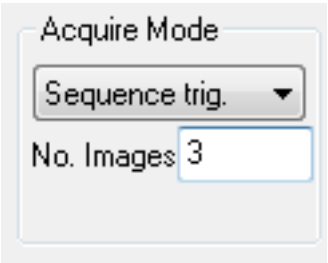


In ***trigger mode External Exp. Ctrl***, the acq enbl input works very similar to the mode ***External Exp. Start***. However, the ***acq enbl*** input is ignored for the edge which is closing the exposure time (started exposure will be finished accordingly).

When using ***acq enbl*** in ***external trigger modes***, the following timing specification should be met:



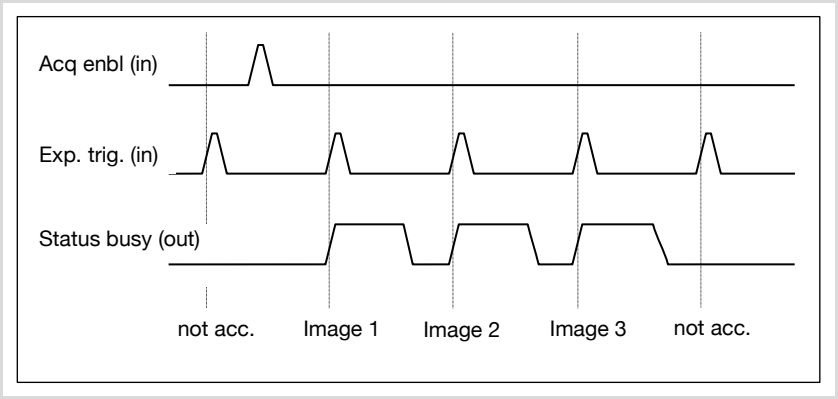
If the ***acq enbl*** signal changes within the window of t_{su} (set up) to t_h (hold), the behavior is random. The trigger may be accepted or ignored.



Sequence Trigger

Once, a falling or rising edge at the ***acquire enable*** trigger input (see chapter **6.6)** is recognized, an internal image counter starts to run. It will count all acquired images and will stop the recording when the predefined number of images is reached.

Example timing diagram: Trigger mode = external exposure start; Aquire mode = sequence trigger; Image counter = 3



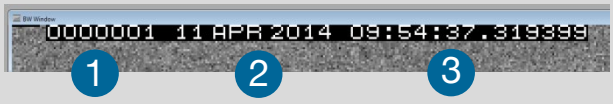
Timestamp ❸

A time stamp can be placed into the upper left corner of the image. It can be either put off, binary or binary with text.

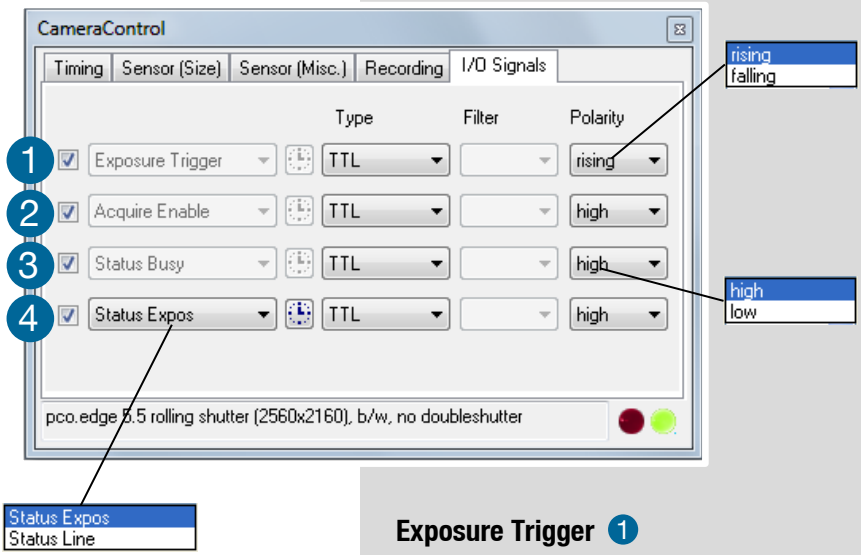
The time resolution is 1µs. In binary mode the first 16 pixels will be filled with the time stamp information (binary code). The numbers are coded in BCD with one byte per pixel, which means that every pixel can hold 2 digits. If the pixels have more resolution than 8 bits, then the BCD digits are right bound adjusted and the upper bits are zero. (1 BCD digit ≙ 4 bits; 2 numbers ≙ 2 BCD ≙ 8 bits = 1 byte; every pixel can hold 2 digits)

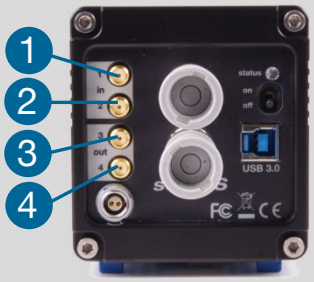
For further information please refer to the SDK.In binary and ASCII mode text will be placed into the image replacing the content of the image (271x 8 pixels). Time step shows the ***end*** of exposure time.

Three different ***information*** is stamped onto the image: number of the image ❶, date ❷ and time ❸.



6.6 THE I/O SIGNALS TAB





Exposure Trigger 1

If checked, a signal for External Exp. Start or External Exp. Ctrl trigger mode (see chapter **6.2**) is accepted at the ***exp trig*** BNC input #1.

Aquire Enable 2

If checked, a signal for Acquire Mode or Sequence Trigger Mode (see chapter **6.5**) is accepted at the ***acq enbl*** BNC input #2.

Status Busy 3

If checked, a signal indicating busy status is given at the status busy output. Once an acceptable trigger edge is received, ***busy*** will go on status ***high***. As soon as busy goes ***low*** again, a new trigger edge is accepted.

Status Expos 4

If checked, a signal indicating exposure status is given at the status output. Status Expos indicates the actual exposure window for one frame.

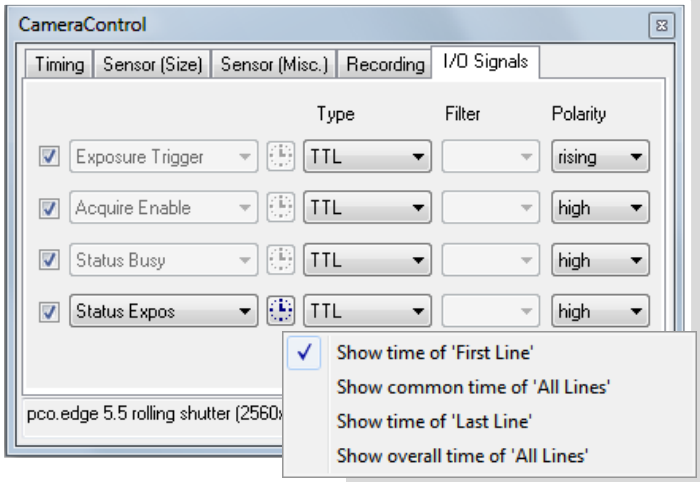
Status Line 4

If checked, a signal indicating line status is given at the status output. Use the falling line edge for optimized synchronization (minimized jitter time; see page **20**).

Filter (electrical interference filters)

Polarity	***Type***
active for high/low signal or rising/falling edge Maximum low level: 0.8V Minimum high level: 2V Slew Rate >1ms/V	TTL Electrically grounded, no opt coupler. 3,3Volt LVTTL out , short time short-circuit-proof. Continuous overvoltage withstand: +10V and -5V. 1ms pulse overvoltage withstand: +33V and -33V ESD pulse: +- 4kV

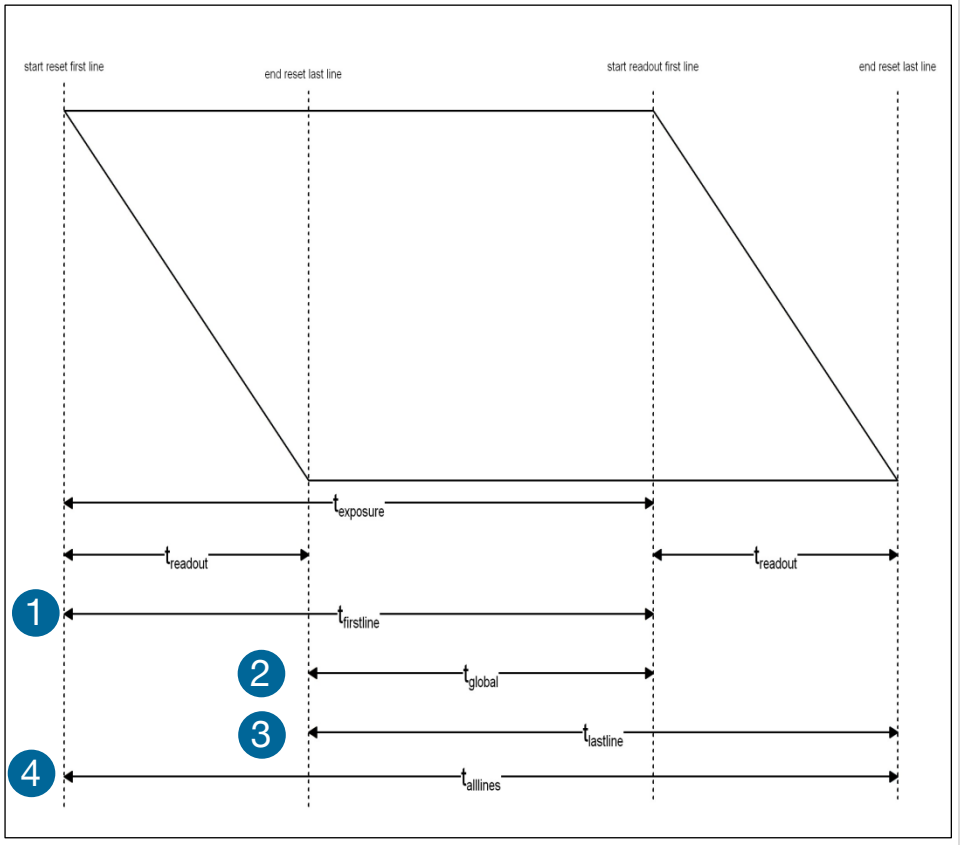
Rolling Shutter signal type



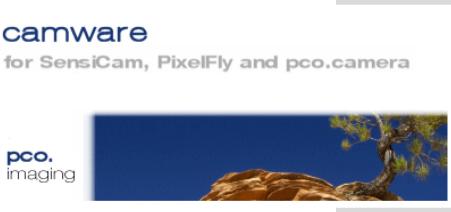
At the I/O-signal tab Rolling Shutter signal type options are available (only Status Exposure and if Shutter is set to Rolling Shutter, see **7.4** Setup.

There are four signal types available:

1. Shows the exposure time of the first rolling shutter line ($t_{firstline}$)
2. Shows when all sensor lines are exposed (t_{global})
3. Shows the exposure time of the last rolling shutter line ($t_{lastlinel}$)
4. Shows if any sensor line is integrating ($t_{alllines}$)



7. CAMWARE FEATURES

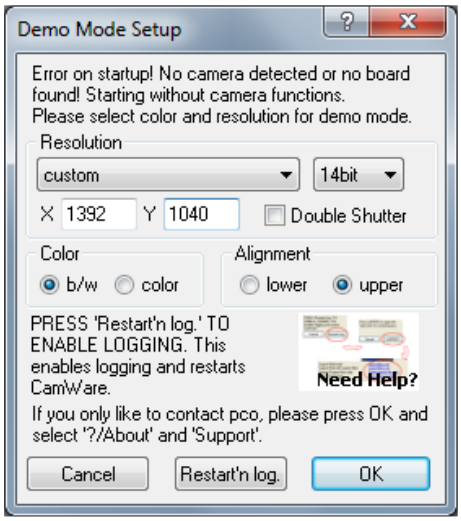


PCO's excellent software for camera control, image acquisition and archiving of images in various file formats.

You will find a **Help file** under the common Help (?) menu.

There are some features explained in the Help file that are not applicable for this camera version.

7.1 IF NO CAMERA IS DETECTED (DEMO MODE)



When CamWare is started, it automatically recognizes the camera type of the connected and running cameras.

CamWare will start in Demo Mode, if your camera is switched off or no camera is connected

In this mode all ***image processing*** features are available, but all ***camera settings*** are deactivated. The user only has to tell CamWare what type of image he wants to open. For that purpose, the ***Demo Mode Setup*** window opens and asks for the corresponding input.

Need Help? If this window pops up because you have trouble running the camera, please see instructions in appendix **A6**.

Resolution
The drop down list displays the existing image sensor spatial resolutions of all PCO camera systems. Please select the specific resolution and bit depth of the images to be opened. If double shutter images have been recorded and should be opened, Double Shutter Mode should be checked.

Color
With the radio buttons, the user can specify whether the image type is monochrome (b/w) or color.

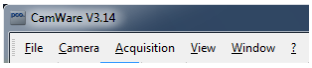
Alignment
These two radio buttons adjust whether MSB (most significant bit) aligned (upper) or LSB (least significant bit) aligned (lower) images have been stored (see **7.3** File Settings).

Example settings to view the b16 files of the pco.edge:

Camera	Resolution	bit	DoubleShutter	Sensor	Alignment
pco.edge 5.5 color	2560x2160	16	<no>	color	-
pco.edge 4.2 mono	2048x2048	16	<no>	mono	-

7.2 OVERVIEW

Menu Bar



See chapter **7.3- 7.8**

Local Menu

Mouse right-click is explained in chapter **7.9**

Toolbar

Prints the currently displayed image or comment window

Opens a ***b/w | color display*** window

Opens the ***camera control*** window (see chapter **6**)

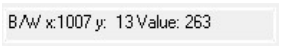
Opens the ***convert control*** (see chapter **7.6**)

Auto range peak/crop (see chapter **7.6** Convert Control)

Live preview (see chapter **5.2**.)

Soft trigger captures a single image (see **6.2**)

Cursor display



Cursor: pixel position and intensity value

Continuous ***auto range crop*** scaling

Recorder

Record ***START / STOP / PLAY***

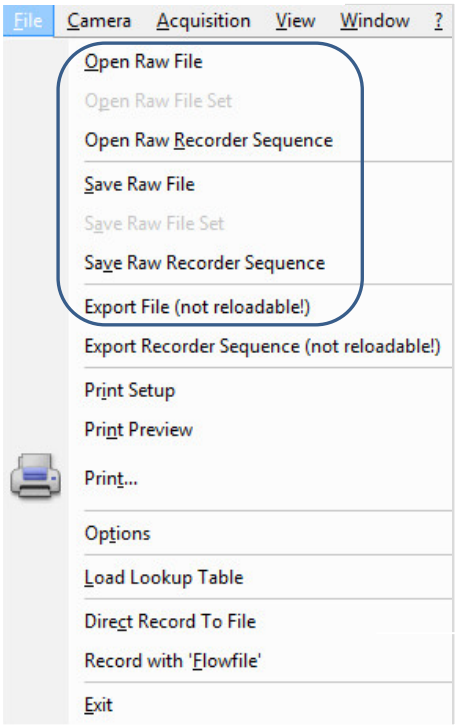
Opens the ***recorder settings*** window (see **7.5**)

Replay navigation

Image Browser: overview of the recorded images (see **7.6**)

Multi Frame Window (see chapter **7.6**)

7.3 THE FILE MENU



NOTE
Be aware of the different storage abilities of the formats, for example *.bmp - the bitmap format only allows for 8 bit values to be stored and therefore the image content of a 16 bit image is reduced, if stored as bitmap.

Open RAW File (single image only)
This command should be used to import a single image into the currently active image window. Only files with the extension and format of ***.b16 (=PCO proprietary binary image format)*** and *.tif (TIFF image format) can be imported. If the recorder is enabled, each imported image will be transferred to the buffer shown in the picture number. The image itself will be fitted to the current image size. If the recorder is disabled, the current image sizes will be set to the parameters of the imported image.

Open RAW File Set (not available)

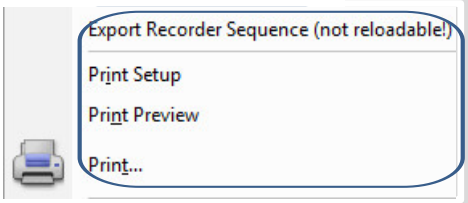
Open RAW Recorder Sequence (image sequence from one camera)
This command is used to import a sequence of images. If more than one camera is connected and an image window is currently open, the sequence will be loaded to the active window. If no image window is open, the images will be loaded to camera #1. This command opens the Open file dialog box. Importable files must have the extension or the format of *.b16 and *.tif (TIFF16).

Save RAW File (single image only)
This command should be used to save the image, which is displayed in the active window. The command opens the Save file dialog box. The image file can be saved in 16bit *.b16 and *.tif format. If more than one camera is connected, it is possible to save all current images by selecting Export all images in the Save file dialog box. With this feature it is possible to save one image of each active camera within one process step (it is not necessary to repeat the save process for each camera). The Save command will not be available, if no image window is open.

Save RAW Set (not available)

Save RAW Recorder Sequence (image sequence from one camera)
The Save Recorder command should be used to save or export image records. If more than one camera is connected and an image window is currently open, the record of the active window will be saved. The command opens the Save file dialog box. The Save Recorder command will not be available, if no image window is open.

Export File (not reloadable!)
Use this command to export the image of the active image window. This command will open the Save file dialog box. Files with the extensions fts, tif, bmp, asc, jpg, and jp2 can be exported. This item will not be visible, if no image window is open

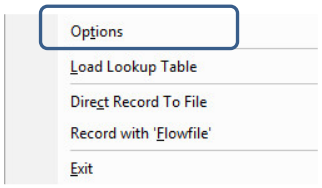


Export Recorder Sequence (not reloadable!)
Use this command to export a sequence of images. If more than one camera is connected and an image window is currently open, the record of the window which has got the input focus will be saved. If no image window is open the images of channel 1 will be saved. This command will open the Export image dialog box. Files with the extensions fts, tif, bmp, asc, avi, mpg, jpg, jp2, and wmv can be exported. (see Appendix **A7)**

Print Setup
The Print Setup command opens the Windows Print Setup dialog box for adjustments and settings of the connected printer(s).

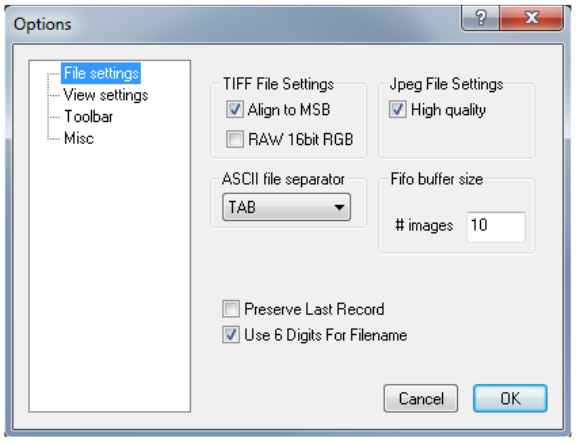
Print Preview This command opens a Print Preview window.

Print Opens the Windows Print dialog box.



This command opens the ***Options dialog***, allowing special settings.

File Settings



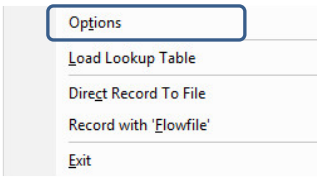
Tiff File Settings: Align to MSB
Here you can select the alignment of the pixel value, if the pixel depth is less than 16 bit (e.g. MSB: each pixel value is shifted from bit 12-1 to bit 16-5 in case of 12 bit). This removes the dark image effect inside other image applications.

Tiff File Settings: RAW 16bit RGB
Here you can select whether the 16bit RGB tiff file is saved with 16bit raw or white balanced data. If this item is checked, each 16bit RGB pixel value is saved as raw 16 bit RGB (48 bit) value, without white balancing. Saving to 16bit RGB can be done by selecting the color display window, export recorder, selecting 8bit-tiff and checking ***Save 16bit RGB***.

ASCII file separator
Here you can select an appropriate separator for the ASCII file format.

JPEG File Settings
Here you can select the quality of the saved jpeg/jp2 files: high quality saves images with 100% quality (otherwise 85% quality).

Preserve Last Record
If checked, a message box will pop up in case the user may overwrite or loose data.



Use six digits for filename
If you record a sequence of *.b16 files and choose direct record to file CamWare is always using six digits for filename (e.g. t_123456.b16).

View Settings

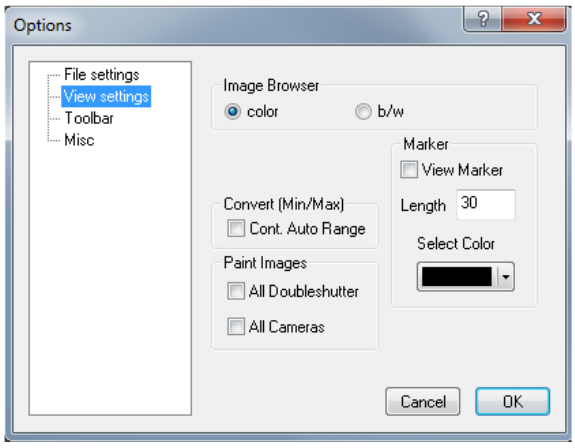


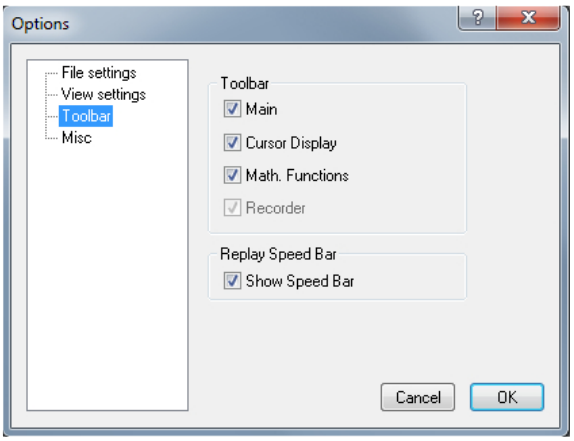
Image Browser
Here you can select between showing all image tiles inside the browser window either b/w or color. Setting b/w will result in a faster refresh, (valid only for color sensor).

Convert (Min/Max)
(***Continuous Auto Range Crop***, see chapter **7.6** ***Convert Control BW***) This option enables the automatic min/max function during record and replay. Disable this feature if the application stops responding during this mode (due to operating system capacity problems).

Marker
Use this command to display a crosshair in the center. It is possible to adjust length and color of the crosshair.

Paint Images
This option enables the update of (both double shutter images or) multiple cameras images during record and replay. Disable this feature if the application stops responding during this mode

Toolbar



Toolbar (Main / Cursor Display)
Opens the corresponding toolbars (see **7.2**)

Math. Functions

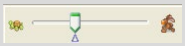
With the math window you have the ability to build the difference between a reference image and the actual image. If you activate math every new image acquired will be subtracted from the reference image or vice versa.

last acquired image will be copied to reference buffer

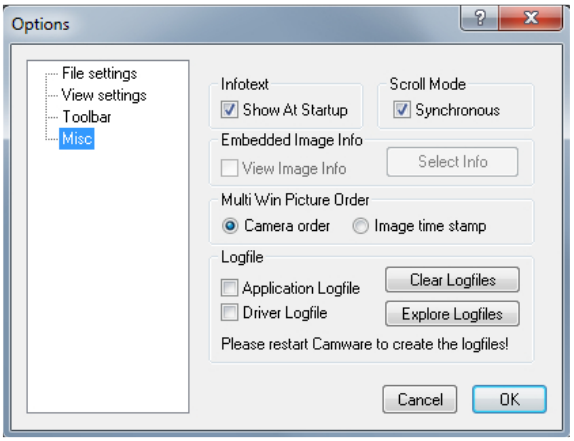
a reference picture will be acquired and copied to reference buffer

add offset to avoid negative values, which would not be visible

enable / disable math function

Replay Speed Bar

The faster replay speed is useful if large sets of image data need to be scanned.

Misc



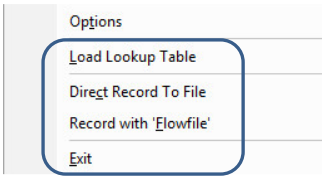
Infotext
Use this command to show or hide the start-up information dialog box.

Synchronous Scrolling
If this item is checked all opened image windows will be scrolled at the same time and in the same manner.

View Embedded Image Info (not available)

Multi Win Picture Order
With the ***Multi Window*** you have the ability to view the images of all active cameras in one window. You can select between ***camera order*** oriented or ***image time*** oriented order. ***Image time*** oriented means that the sequence of images depends on the individual time stamp of each image. ***Camera order*** oriented means that the first image shown is from camera 1, then camera 2 and so on.

Logfile
This option enables the logging of errors and system info. Enable this feature in order to create a support file, which can help to find out troubles with the camera (see **A9.2**)



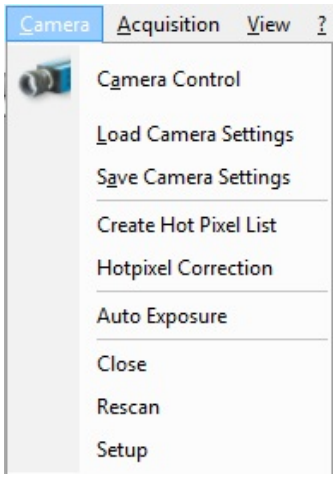
Load lookup Table (for monochrome cameras)
With the Pseudo LUT (Lookup-Table) feature you can load any LUT with one of four different formats and you can view the result in the color view window.

Direct Record to File
With this command you can pre-set a certain number of images to be stored directly onto hard disk. If the camera captures images faster than the computer can save to disk, then you will lose images. The displaying of the images doesn't interfere with the record process. (See also **6.5** Recorder Mode and PC recommendations in **A4.2** Image Data Flow). Use this command to write data to your RAID system.

Record with Flowfile
This command should be used to load a flow file. A flow file contains lines with a delay and an exposure time. Each line corresponds to one image to be acquired. If the flow file has 15 delay and exposure times than 15 images will be acquired. Before the image is snapped, the corresponding time values will be sent to the camera. This affects the possible image frame rate, as additional time is required for setting the values between two images. Please see the sample flow files in the application directory (e.g. flow.txt).

Exit
This command exits the program and closes all channel dialog windows. Window positions, settings and sizes are stored in the windows registry and will be loaded again at next start-up.

7.4 THE CAMERA MENU



Camera Control
Use this command to open the camera control window (see **6.1**).

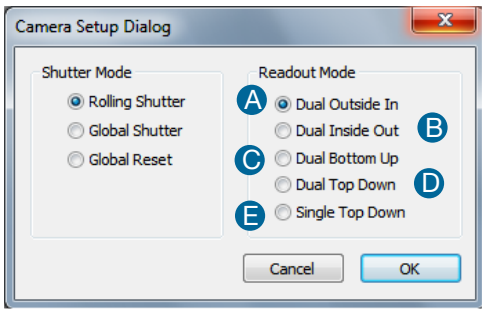
Load Camera Settings
With this command you can reload camera settings which have been previously saved. You can reload only a file which has been made with the same camera configuration as it was found by the application at start-up.

Save Camera Settings
This command saves the actual camera settings of all connected cameras.

Create Hot Pixel List (for long exposure only – not available)

Hotpixel Correction (for long exposure only)
Sophisticated hot pixel correction is already implemented in the pco.edge camera.

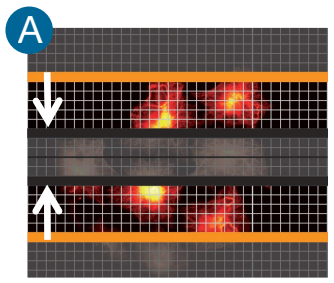
Auto Exposure
Starts some exposures and tries to find an exposure time that captures images with grey values between 1400 and 1500. It re-adjusts the lookup tables in order to display the images with the new settings best. For low light conditions only.

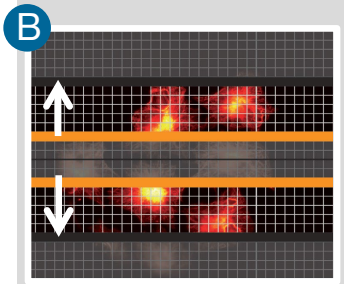


Close
Disconnects camera and switches CamWare to Demo Mode. In case of multiple cameras, all cameras must be closed in order for CamWare to switch to Demo Mode.

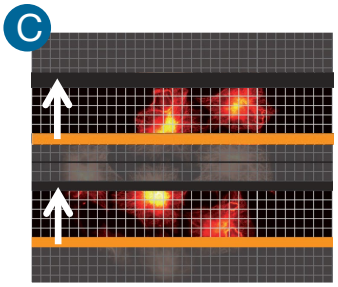
Rescan
Disconnects and reconnects all cameras.

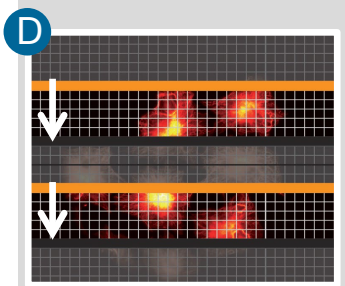
Setup
Switch between Rolling Shutter, Global Shutter and Global Reset Mode. The camera will automatically restart.

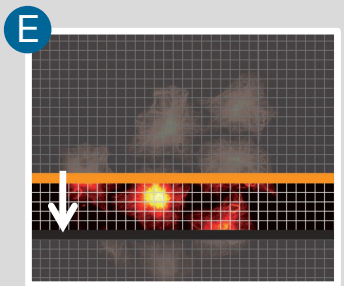




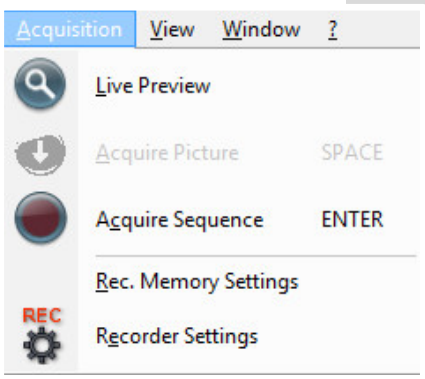
Five different readout modes are available in ***Rolling Shutter*** (**6.2.1**). Standard mode is ***Dual Outside in***. In ***Single Top down***, the pco.edge provides only half of the normal frame rate. CamWare rotates the image that was recorded by the sensor, by 180°. This means, that the last line of the image is the first line of the sensor. PCO SDK names are from A to E.







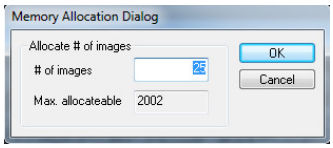
7.5 THE ACQUISITION MENU



Live Preview
The ***Live Preview*** is useful for fast and easy adjusting and focusing of the camera. The active window will be updated. To see another window, simply click on the window. This option is not available in double shutter mode.

Acquire Picture (not available)
Records single images in case of sensicam cameras.

Acquire Sequence
Starts recording images into the system memory according to Trigger Mode selection (see **6.2**). During the recording, the camera controls are locked.



Rec. Memory Settings
This sets the number of images recorded in one sequence. The maximum is defined by approved RAM size.

Recorder Settings
This command opens the Recorder Settings dialog window.

The ***Play Settings*** are referred to the camera. If more than one camera is connected, the camera number is retrieved from the image window that has received the input focus (is active). If no image window is opened, the dialog is referred to camera 1. If the ***Set to all*** checkbox is checked the settings apply to all connected cameras.
The ***Global Settings*** are valid for all connected cameras.

Averaging
If in the ***Avg***. dropdown list a value not equal to 1 is selected, the corresponding number of images is averaged in the buffer, reducing the statistically independent noise.

Another option to reduce the noise is the activation of the ***Infinite impulse response IIR lowpass filter***. This filter takes 90% of the previous image and 10% of the new image to create images with clearly reduced noise. Image (actual) = Image (act - 1) * 0.9 + Image (new) * 0.1

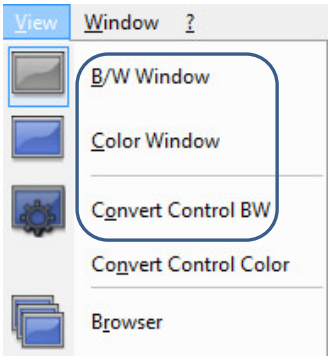
Replay Speed Slider
The slider can be used to adjust the sequence replay speed, from slow (turtle) to fast (rabbit).

Seq. Wrap Rec
Sequential Wrap Recording sets Recorder Mode (**6.5**) to Ring Buffer.

Seq. Wrap Play
The play button starts the display for a sequence as defined by the first image/last image fields and will loop until the stop button is pressed.

Reverse Play
If checked, it is possible to play the recorded images in reverse order.

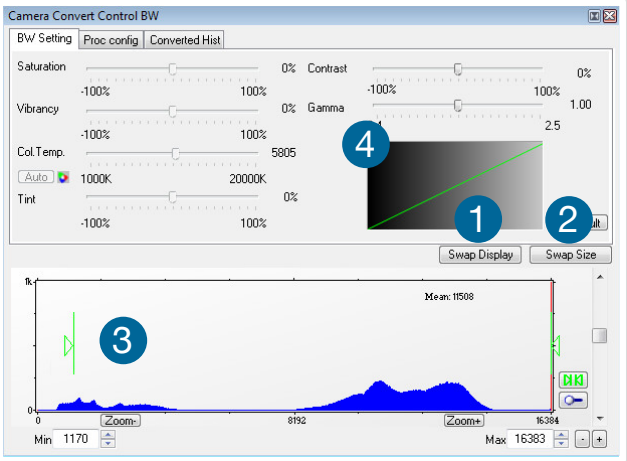
7.6 THE VIEW MENU



B/W Window
Use this command to open a b/w display window.

Color Window
Use this command to open a color display window.

Convert Control BW
The user can influence how the 16 bit intensity values (x-axis) of the original image are converted into 8 bit values (y-axis) in different ways.



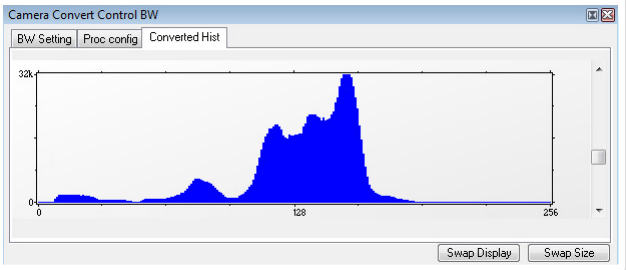
BW Settings (includes histogram of original data)

It is possible to hide the histogram of original data (1) ***and to*** switch tab/histogram (2).

Green sliders in histogram (3)
left slider = Min controller (corresponds to value 0 of the 8 bit display). Values below that mark are set to 0, i.e. displayed as black.
right slider = Max controller (corresponds to value 255). Values above that mark are set to 255, i.e. displayed as white.

The values in-between are converted into a value between ***0*** and ***255*** according to ***Contrast*** and ***Gamma*** settings. See the small ***graph*** (4), which reflects the calculation.

Proc config tab: please see ***Convert Control Color*** on the next page.



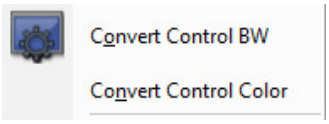
Converted Hist
This tab shows you the ***histogram of converted data.***

How the Auto Range applies

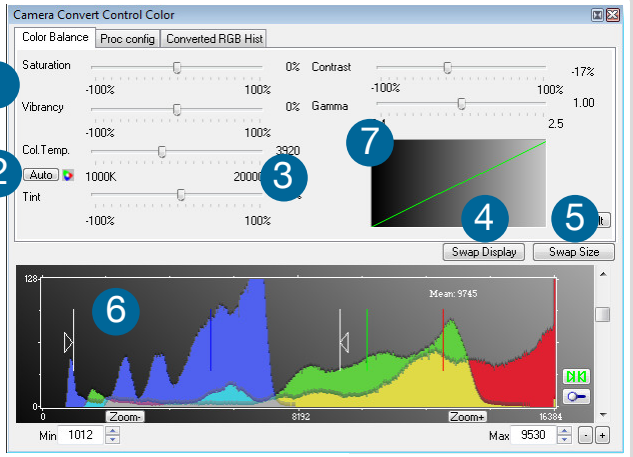
Auto Range Peak searches for the minimum and maximum 16 bit intensity values of the image. Given these number the converter scales the 8 bit display (256) within these two values.

Auto Range Crop sets the converter to ignore the extreme intensity values of the image and scales the display in a smaller range. Thus dark or bright light spots, reflections, etc. are cut off.

Min/Max (Automatic) = Continuous Auto Range Crop



Convert Control Color (only pco.edge color)



Color Balance (Histogram of original data)

Intensity of single color can be controlled by ***Saturation*** and ***Vibrance*** (1).

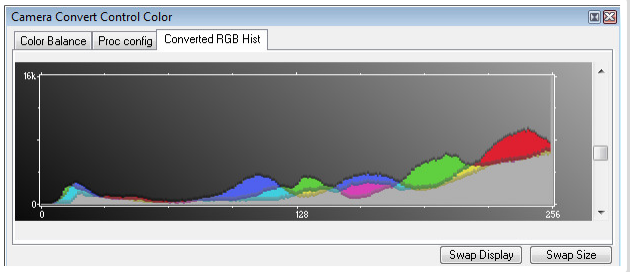
Press the Auto button to set the ***white balance*** (2).

The balancing of RGB can be controlled by ***Col.Temp*** and ***Tint*** (3).

It is possible to ***hide the histogram of original data*** (4) and to ***switch tab/histogram*** (5).

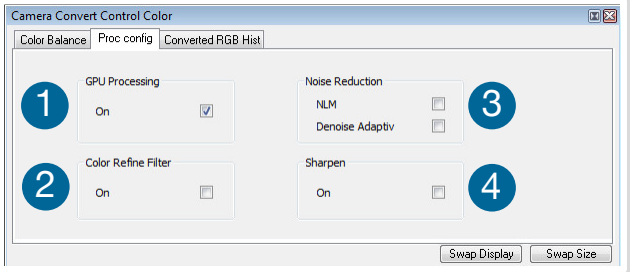
The user can influence how the 16 bit intensity values (x-axis) of the original image are converted into 8 bit values (y-axis) in different ways.

White sliders in histogram (6)
left slider = Min controller (corresponds to value 0 of the 8 bit display). Values below that mark are set to 0, i.e. displayed as no color.
right slider = Max controller (corresponds to value 255). Values above that mark are set to 255, i.e. displayed as full color.
The values in-between are converted into a value between 0 and 255 according to ***Contrast*** and ***Gamma*** settings. See the small ***graph*** (7), which reflects the calculation.

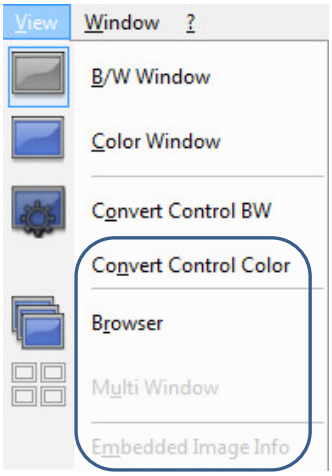


Converted RGB Hist
This tab shows you the ***histogram of converted data.***

Proc. Config (Process configuration)
Due to proprietary high-end algorithms used for these image processing features, no detailed description is given here.



1. switch on in order to significantly reduce processing time
2. pixel color correction
3. non local means algorithm
4. adaptive to brightness and patterns



GPU Processing
In order to benefit from all of CamWare's advanced processing features, we highly recommend a NVIDIA CUDA-enabled graphics processing unit (GPU). AMD's ATI graphics processing units are not recommended.

Find a list of CUDA-enabled products here:
- https://developer.nvidia.com/cuda-gpus

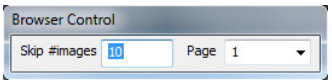
Get the CUDA driver here:
- https://developer.nvidia.com/cuda-downloads

Make sure:
- that the CUDA driver is successfully installed.
- that the GPU has at least 512MB memory.

CamWare Image Processing

	color	monochrome
Pre Processing		
• Noise Reduction	✓	✓
Bayer Processing		
• Bayer Demosaicing	✓	
• Sharpen	✓	
• Refine Process	✓	
• Chroma Blurr	✓	
Post Processing		
• Offset, Gain (Min/Max)	✓	✓
• Color Correction	✓	
• Saturation, Vibrance	✓	
• Color Temperature, Tint, White Balance	✓	
• Gamma, Contrast	✓	✓

Browser
The ***Recorder Browser*** gives an overview of the images in the Recorder, and helps you in an easy way to select a new current image. Simply click on the desired image to make it the current image. It may then be viewed in the Black/White and Color Window.
The Browser window can show up to 40 pictures per page, thus enabling easy printing of the Browser window. You can switch between the single pages by double clicking inside the Browser window or with the local menu (right mouse button).

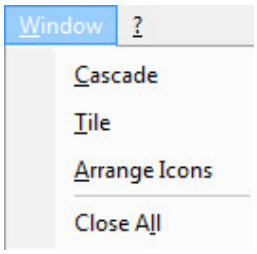


Skip #images allows for convenient overview at large numbers of images.

Multi Window
View the images of all active cameras in consecutive order in one window. Time oriented means that the sequence of images depends on the individual time stamp of each image. Camera number oriented means that the first image shown is from camera 1, then camera 2 and so on.

Embedded Image Info (not available)

7.7 THE WINDOW MENU



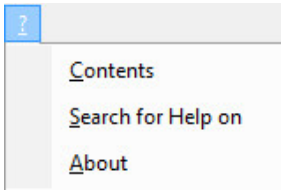
Cascade
Show all windows overlapped.

Tile
Tile windows vertically or horizontally.

Arrange Icons
Rearranges all minimized topic icons on the desktop.

Close All
Close all windows.

7.8 THE HELP MENU



Contents
Opens the main page of the program help.

Search for Help on
Opens an index list for help.

About CamWare (64bit) Ver.: 3.16, Build Nr. 0129
OK
camware
use this software to control all available versions of SensiCam, DICAMPro, PixelFly and pco.camera.
(c)1998-2012 pco ag
Support (Mail only): support@pco.de
Support (Mail with support files): support@pco.de
Support (Support files only): Create support files only
Visit our homepage: http://www.pco.de
Warning: This program is protected by copyright law and international treaties.
Unauthorized reproduction of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extend possible under law.
Copyright (c) 2015 PCO AG; The licensee is granted a non-exclusive and non-transferrable right to install the software and use it as an application.

About CamWare
This window shows program information and contains helpful support links. In case of a camera problem, support files (see **7.3** Options/Misc/Logfile) may be generated, which can be automatically attached to the email. The support files contain relevant hardware information, the log files and the PCO related registry entries. These files are moved into a zip-archive called ***CWSupport.zip***, which can be found in the application folder.

7.9 THE LOCAL MENU

The local menu is opened by clicking the right mouse button inside the client area of an image window.

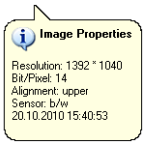
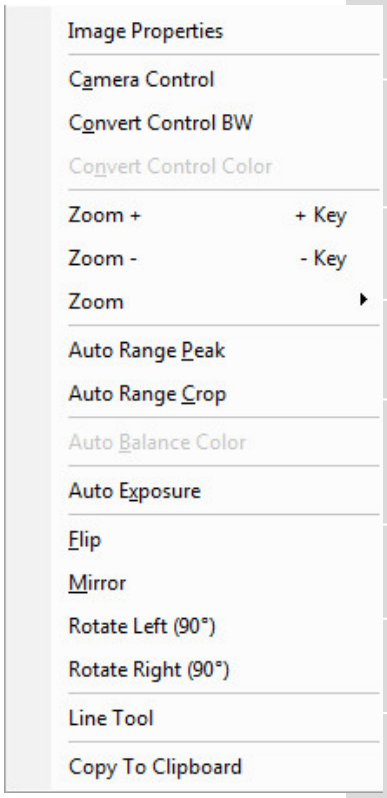


Image Properties
Opens an information bubble with main image properties and activates the ***in-image display***. It does not overwrite image data.

All camera link cameras generate the image properties out of CamWare (Camera Description, see SDK manual for further information) and the PC system time. In case a pco.edge with USB 3.0 interface is connected, the image properties and other metadata is transferred from the camera directly. One additional ***line***, which contains all image properties, will be sent from the camera after the image data is transferred.



Camera Control
Opens the Camera Control window (see chapter **6**).

Convert Control BW/Color
Opens the corresponding Convert Control windows (see chapter **7.6**).

Zoom
Changes the zoom used to display the image.

Auto Range Peak/Crop
Displays the image in a predefined scaling (see chapter **7.6**).

Auto Balance Color (only available for pco.edge color)
The white balance feature, which corresponds to the white balance button in the ***Convert Control Color*** (see chapter **7.6**).

Auto Exposure
Auto Exposure feature (see chapter **7.4**)

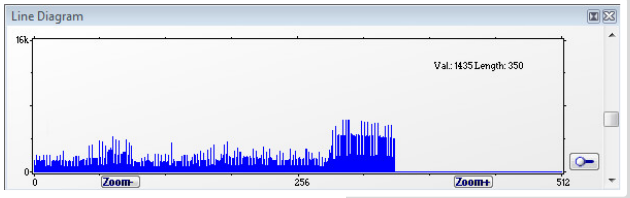
Flip
The image will be flipped before display.

Mirror
The selected image will be mirrored before display.

Rotate
The image will be rotated by 90° counter clockwise (left) or clockwise (right) before it is shown in the image window.

Copy To Clipboard
Copies the active image to clipboard ***(only as 8 bit image file).***

Line Tool

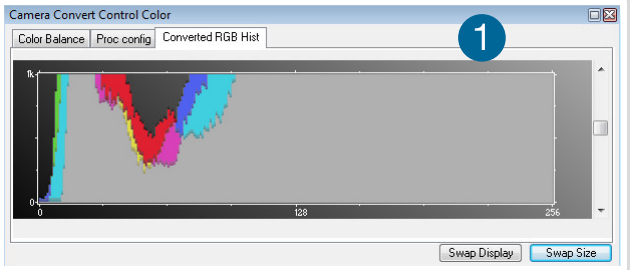


Select ***Line Tool*** to show a graph, which shows the intensity of the pixels under the red line shown in the image window. The selection of this menu item determines the location of the first point. After this you can move the mouse to the second point, which can be selected by a ***left click***. Now a ***Line Diagram*** opens and the length of the line (unit: pixel) is shown in a bubble and displayed in the window.

7.10 ADDITIONAL FEATURES

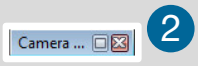
White Balance by Mouse

It is possible to change ***white balance*** easily by mouse: You only have to press the CTRL (Strg) and the shift button at the same time and select a white or gray area within the image. The pixel values within the coordinates of the selection rectangle are used for calculating a new ***white balance***.
For best results we recommend to use the white balance button in the Convert Control Color (see **7.6**) or the Auto Balance Color in the Local Menu (see **7.9**) respectively.



Fold Up Window

The Convert Control windows can be minimized / folded up 1. Just move the pointer over the bar and the window will unfold again 2.



Setting Contrast Area by Mouse

You can control the minimum and maximum values used for the conversion from 16 bit to 8 bit with the mouse. Move the mouse cursor into a region which should be shown with maximum contrast. Press the shift and the left mouse button. Hold down the mouse button while increasing the size of the selection rectangle with mouse moves. After releasing the mouse button the coordinates of the selection rectangle act as a border for calculating the minimum and maximum values.

Setting a new ROI by Mouse

In the same manner you can setup a new region of interest (see ***ROI***) for the camera. You only have to press the CTRL (Strg) button and drag an area with the left mouse button instead of the shift button. The coordinates of the selection rectangle are used for calculating a new region of interest, which will be adapted to the camera capabilities automatically. You can reset the ROI to maximum by pressing the CTRL (Strg) button and the right mouse button.

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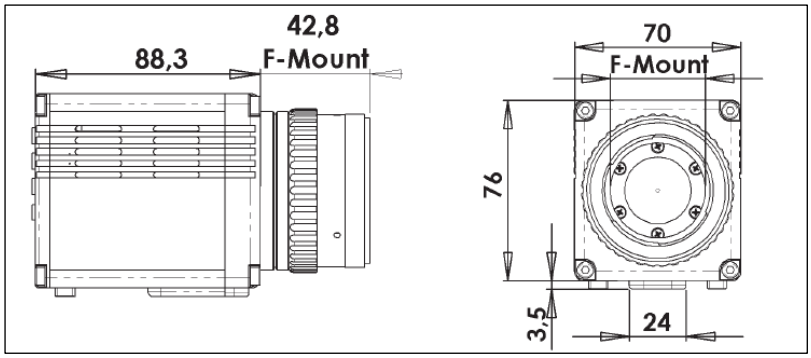
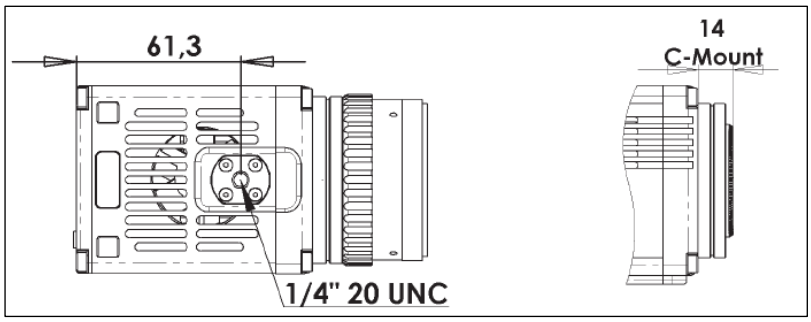
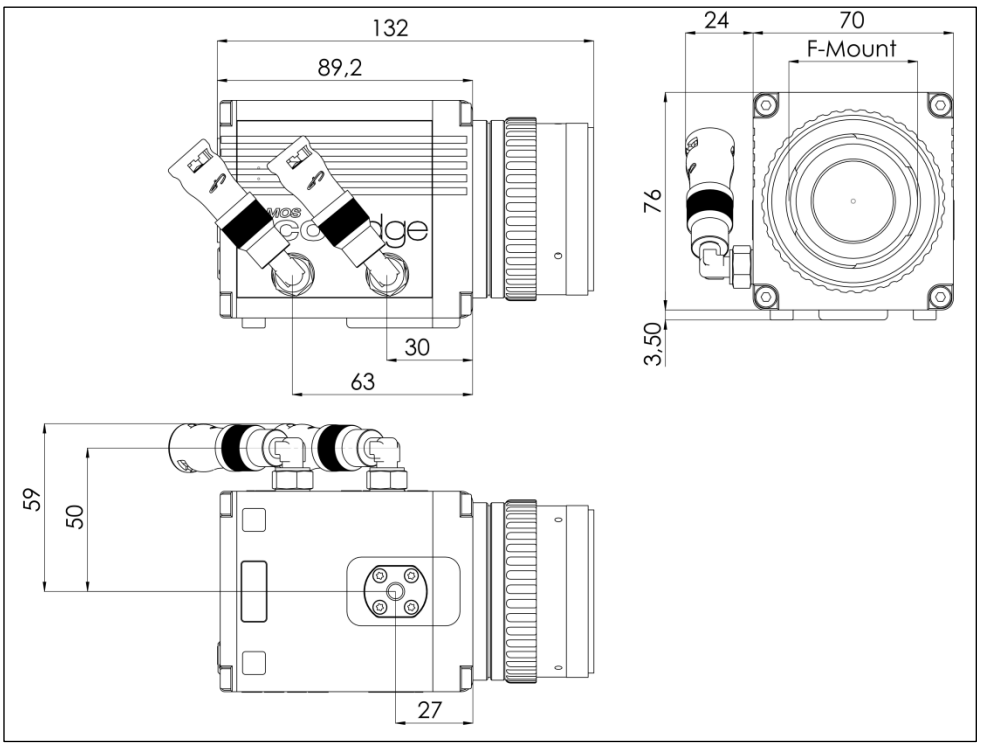
A1 MECHANICAL DIMENSIONS

Standard Version (pco.edge 3.1/ 4.2 (LT) / 5.5: Camera Link or USB 3.0)

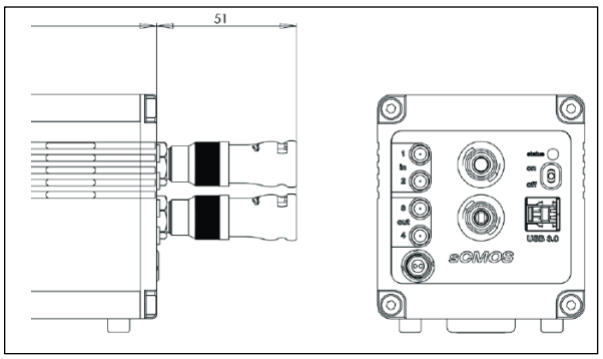




Water Cooled Standard Version (pco.edge 4.2 / 5.5 Camera Link)

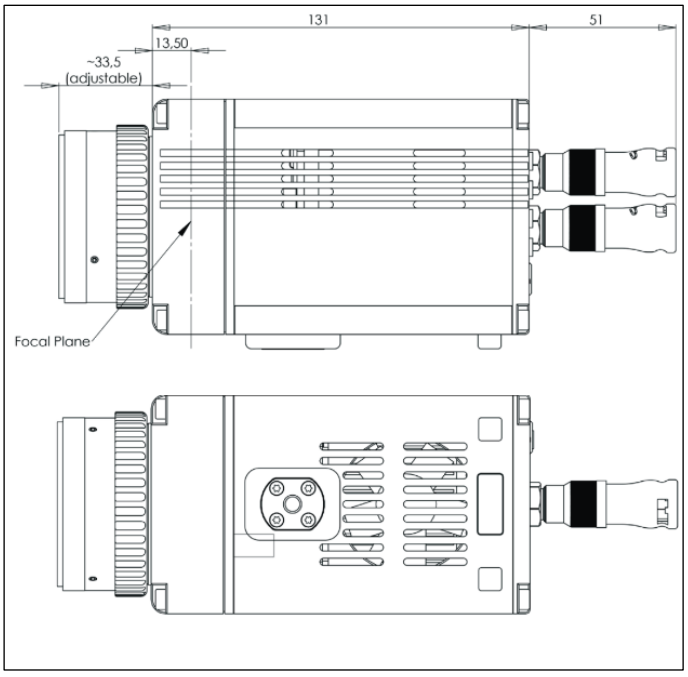


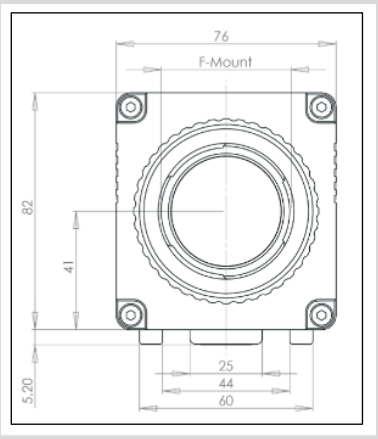
Water Cooled Standard Version (pco.edge 4.2 / 5.5, USB 3.0)

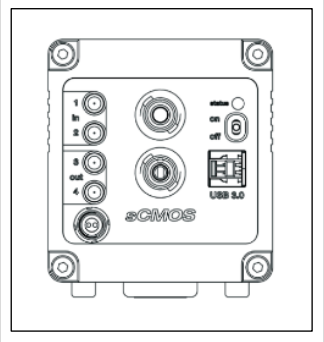


The housing size is similar to the dimensions of the standard version, except the camera design with the USB 3.0 interface allows to locate the water connections on the back of the camera.

pco.edge GOLD series (USB 3.0)

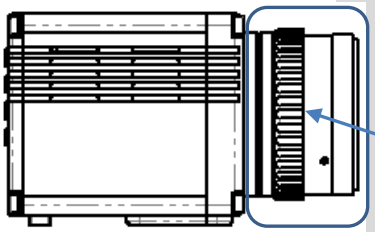






A2 CHANGE FROM F–MOUNT TO C–MOUNT

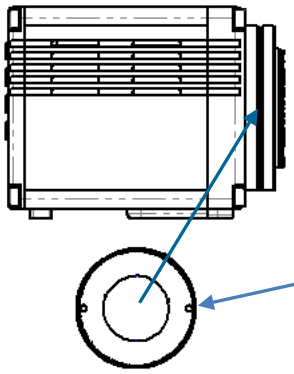
Instructions on how to change the optical input from ***F-mount to C-mount***:



Step 1: Remove F–mount Adapter

Grasp the F-mount adapter at the blue ring (counter ring) and turn it counter clockwise.

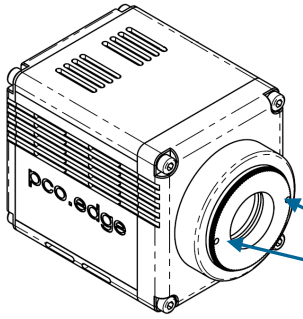
F-mount adapter



Step 2: Insert C–mount Ring

Carefully screw the ring completely in and tighten the two ***Allen screws***.

C-mount ring



Adjust Back Focal Length

First of all, attach a lens to your c-mount adapter. Then set the focus of your lens to infinity. After that, look for a point in infinity* and generate a sharp image by turning the smaller ring of the adapter. Then fix this position with the two small indented screws.

*rule of thumb: object should be away about 2000 times the focal length in mm

Allen screws

Limitations of C–mount lenses

Keep in mind that c-mount lenses could cause shadings at the edges of big sized sensors. Most c-mount lenses are able to illuminate a maximum image circle of 11 mm (2/3”), 16 mm (1”) or 22 mm (4/3”) diameter only. The pco.edge cameras have a sensor diagonal from 18.8 to 21.8 mm, it follows that you have to use the ROI function for a shade less image while using the c-mount adapter with the two smaller C-mount diameters.

A3 WATER COOLING OPTION PCO.AQUAMATIC II

A3.1 SYSTEM COMPONENTS

This is the re-cooling system for pco.edge cameras with water-cooling.

	Material No.	Description
1	30108000211	pco.aquamatic II
2	30108000212	Connection Tube 5m PVC 3541-01 PCO (with Colder NS212 fittings)
3	50402000055	Power supply ETC 70-12 1.2m
4	20307500024	Power cable
5	10307000130	EDGE WAT camera cable 5m FGG-RG58-NC3MX
6	10305000190	Innovatec Protect IP 1L

The operation of the ***pco.aquamatic*** is simple and uncomplicated. Normally no maintenance and nearly no attention are needed. Only the liquid level of the reservoir (water tank) should be controlled from time to time.

Only use *Innovatec Protect IP* for the pco.aquamatic! Do not use or add any other cooling liquid or normal water! If you need to add cooling liquid in order to maintain level in the tank, please contact PCO for additional supply.

The cooling liquid will turn yellow after some hours of operation. This is normal and no sign of wear or malfunction. The optimum pH-value is between 8 and 9 (please check this value if you are concerned about the cooling liquid quality).

NOTE
The recommended service interval for the change of the cooling liquid is four years.

A3.2 FIRST TIME INSTALLATION

Please take care to situate the unit on a flat and firm surface. Do not cover the air intakes of the unit. Please ensure free airflow around the pco.aquamatic to ensure maximum cooling performance. All tubes and power cords need to run kink-free.

Before installation of the unit carefully read the ***Innovatek Protect IP safety*** datasheet (see Innovatek Website).

outlet flow

inlet flow

Please follow steps 1 – 6.

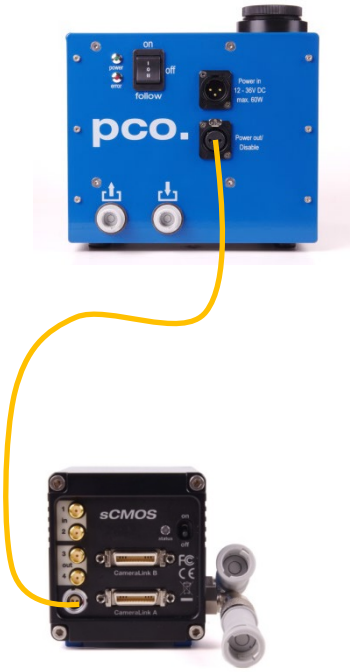
1. Connect tubes to cooling unit and camera. The two arrows on the housing of the cooling unit only indicate flow direction. Either connection of the camera can be used for ***in*** or ***out***.
2. Attach power connection.
3. Open tank cover.
4. Turn power switch to ***on*** position (I).
5. Slowly fill in the cooling application mixture while the unit is running, you have to constantly refill liquid.
6. While the cooling liquid flows back to the reservoir make sure that the whole air escapes from the system – this takes a few minutes (move hoses if necessary).

The cooling liquid reservoir (tank) is filled when liquid level is approximately 1-2 cm from the top of the tank. The integrated pump only works when the pump chamber is completely filled. To ensure this please move hoses or remove air by evacuating. Reservoir capacity is approximately 500 ml.

After ***steps 1 – 6*** are completed successfully the system is ready for ***operation***.

NOTE
The hose connectors are waterproof in not connected state. Maybe they lose one drop of cooling liquid from time to time. You don't have to empty the hoses while storing the camera system.

A3.3 OPERATION



First connect the ***power out*** of the cooling unit with the ***power in*** of the pco.edge camera by using the *PCO WAT camera cable*.

The cooling unit provides two operation modes.
Operation Mode on: the cooling unit is turned on permanently and provides the camera with power. Your camera can be switchted on and off as needed.

Operation mode follow: the cooling unit will turn on when the camera is switched on and vice versa.

Error Codes

The coolant temperature sensor is located in the water tank.

Temperature	Action
27°C	fan turns off
36°C	fan turns on
55°C	warning message
60°C	error message

If a ***warning level*** is passed, the Power LED blinks slowly and the Error LED displays the error code. If a ***failure level*** is passed, the Power LED blinks fast and the Error LED shows the error code.

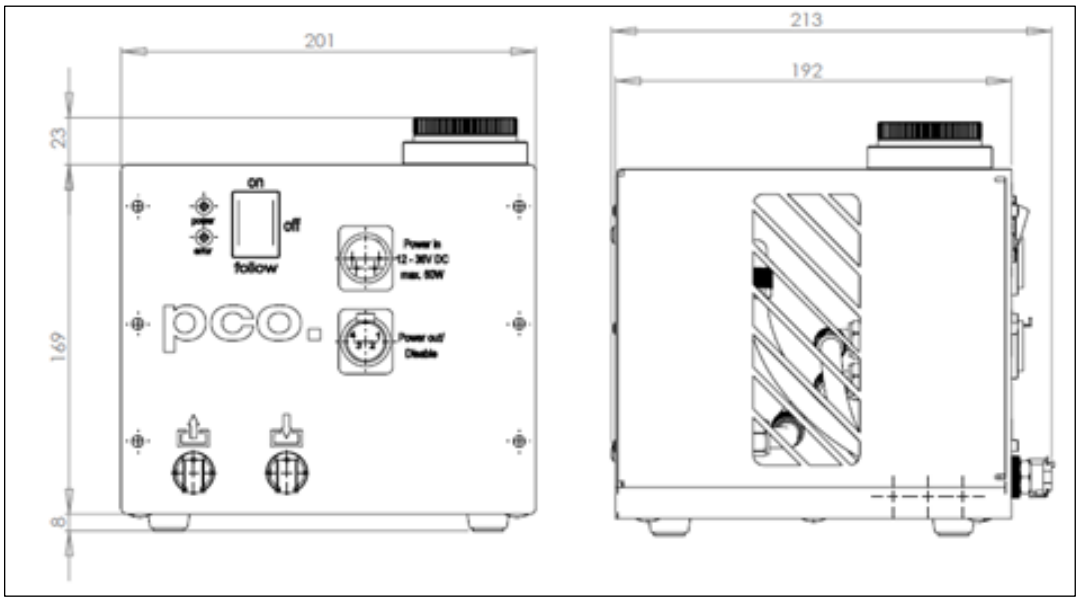
power	error	Error / Failure
on	off	**none**
1Hz flash	one short flash	Warning when temperature at 55 °C (also if sensor is defect or missing)
2Hz flash	one short flash	Failure when temperature at 60 °C
1Hz flash	two short flashes	Fan speed (also if a high deviation of the standard value is reached)

NOTE
The camera has its own protection circuit and will shut down Peltier cooling automatically when the electronics temperature exceeds safety level. The camera itself will keep on running, but sensor temperature will increase. (valid for air and water cooling!)
If the camera and the water cooler have a different power supply, always first shut down camera and then the cooling system to avoid damages.

A3.4 DIMENSIONS

All dimensions are given in millimeter.

Weight: 4kg (completely filled cooling liquid tank)



General Information

You are not restricted to purchase the pco.aquamatic system - it is possible to use an own water cooling solution. A separate power supply will be provided to every pco.edge camera with water connectors. The hardware of the pco.edge cameras with USB 3.0 Interface is designed to work with or without a water cooling system, because a fan that provides adequate cooling is inside the camera anyway. Please note, that the minimum sensor temperature of the pco.edge GOLD series is depending on the cooling system.

In case you use an own water cooling system, please make sure that the liquid you use to cool your camera is at all times NEVER below the dew point of the ambient temperature! In order to avoid any appearance of condensation, use a cooling liquid at room temperature. A liquid flow rate of 1–2 litres per minute is sufficient.

A4 CAMERA LINK

A4.1 INSTALLATION OF FRAME GRABBER

NOTE
Hardware Installation must be performed by a technician, because high voltages can occur on the device. Always pull the main plug before opening the device.

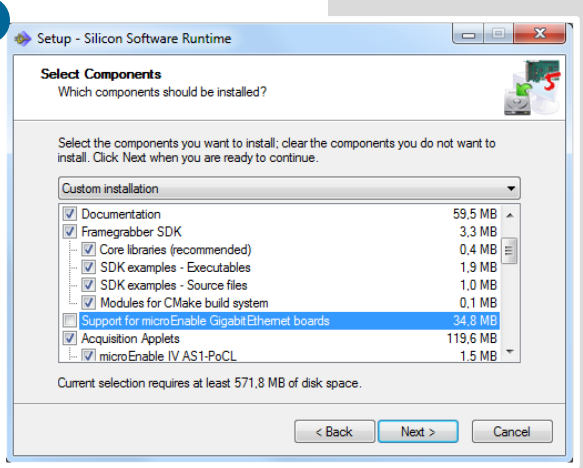
Instructions for installing and testing the ***SILICONSOFTWARE microEnable IV (ME4)*** Camera Link grabber card.

Please install the latest silicon software runtime package before installing the hardware. (Download: www.pco.de/support)

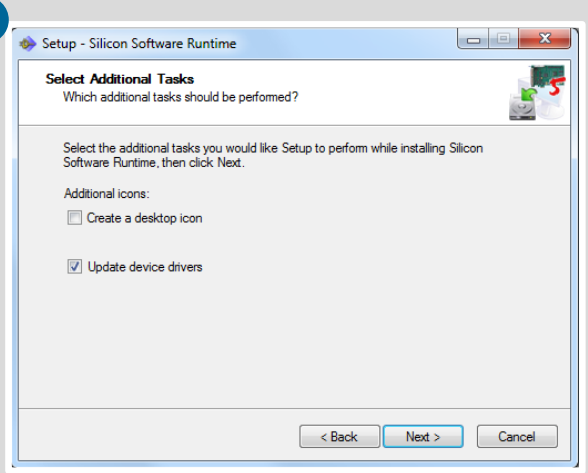
When working on a 64 bit operating system, please make sure to install the proper (64 bit) runtime when also a 64 bit application will be operated. If the application is 32 bit, you need to install the 32 bit runtime accordingly.

1. If there is no ***Gigabit Ethernet*** board installed (standard), please deselect ***Support for…***
2. Let the program also update device drivers.
3. Shutdown your computer, open the computer case and install the ***grabber card***
4. The grabber card should be displayed within the device manager. If the device is not shown this way, please reinstall the ***SiliconSoftware device driver***.
5. After the installation, please start the program ***microDiagnostics***. (see next page)

1

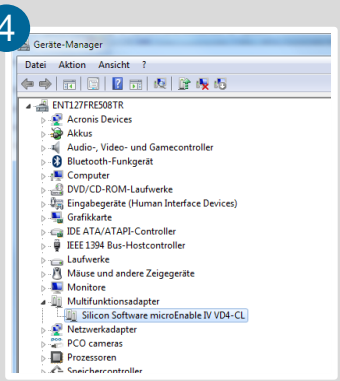

Setup - Silicon Software Runtime
Select Components
Which components should be installed?
Select the components you want to install; clear the components you do not want to install. Click Next when you are ready to continue.
Custom installation
Documentation 59,5 MB
Framegrabber SDK 3,3 MB
Core libraries (recommended) 0,4 MB
SDK examples - Executables 1,9 MB
SDK examples - Source files 1,0 MB
Modules for CMake build system 0,1 MB
Support for microEnable GigabitEthernet boards 34,8 MB
Acquisition Applets 119,6 MB
microEnable IV AS1-PoCL 1.5 MB
Current selection requires at least 571,8 MB of disk space.
< Back
Next >
Cancel

2

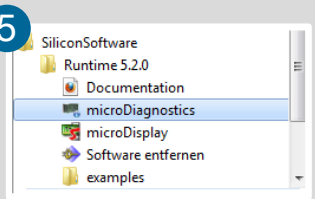

Setup - Silicon Software Runtime
Select Additional Tasks
Which additional tasks should be performed?
Select the additional tasks you would like Setup to perform while installing Silicon Software Runtime, then click Next.
Additional icons:
Create a desktop icon
Update device drivers
< Back
Next >
Cancel

3

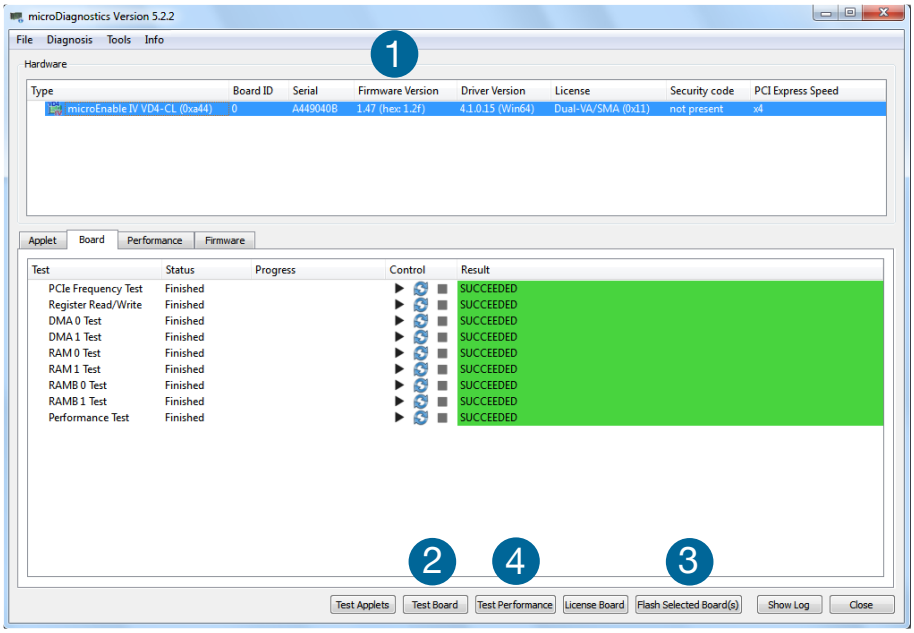
4



5



How to use microDiagnostics Tool


microDiagnostics Version 5.2.2
File Diagnosis Tools Info
Hardware
Type Board ID Serial Firmware Version Driver Version License Security code PCI Express Speed
microEnable IV VD4-CL (0xa44) 0 A449040B 1.47 (hex: 1.2f) 4.1.0.15 (Win64) Dual-VA/SMA (0x11) not present x4
Applet Board Performance Firmware
Test Status Progress Control Result
PCIe Frequency Test Finished SUCCEEDED
Register Read/Write Finished SUCCEEDED
DMA 0 Test Finished SUCCEEDED
DMA 1 Test Finished SUCCEEDED
RAM 0 Test Finished SUCCEEDED
RAM 1 Test Finished SUCCEEDED
RAMB 0 Test Finished SUCCEEDED
RAMB 1 Test Finished SUCCEEDED
Performance Test Finished SUCCEEDED
1
2
4
3
Test Applets
Test Board
Test Performance
License Board
Flash Selected Board(s)
Show Log
Close

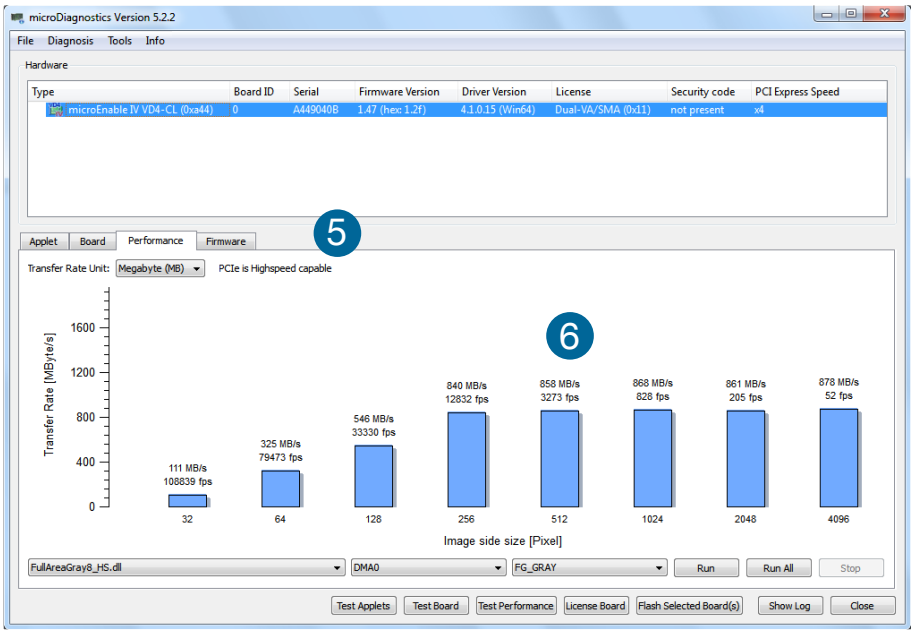
Please verify the firmware 1 version, which must be ***1.40*** (1.28 in hex) or above.

To test the board, select the board in ***Hardware*** 1 and click ***Test Board***. 2

If the firmware is not 1.40 (1.28 in hex), please upgrade to the latest firmware. Select ***Flash Board(s)*** 3, then select the grabber in the dialog and open the appropriate hap file.

Then click on ***Yes*** when you're asked to proceed. You must power cycle your computer after the upgrade.

In case the firmware version is ok, please click on ***Test Performance***. 4



It is mandatory that ***PCIe is Highspeed Capable*** 5 is shown. Otherwise the board is probably not able to transfer the necessary data rate.

The transfer rates, as shown, should be displayed. 6

For further information or problems with mainboards please contact our support section.

A4.2 IMAGE DATA FLOW

The ***sCMOS image sensors*** provide an extremely high frame rate compared to other scientific image sensors. The high frame rate, along with the high dynamic, creates a large amount of data that must be handled and stored. The maximum data rate of the sCMOS image sensor is given by:

pco.edge 5.5 Camera Link:

[2560 * 2160 (pixel in 1 frame) * 2 Byte (= 16bit dynamic)] * 100 [frames/s] = 1.1 GB/s (pco.edge 5.5, Camera Link)

To handle this considerable amount of data, there are ***two options*** available:

Option 1: Real-time Recording to Computer

The pco.edge sCMOS camera series uses this option. For this purpose, the interface must be capable of transmitting data at the required speed. Interfaces such as GigE, USB 3.0 and Camera Link are not fast enough to transmit this data, which is delivered by the largest sCMOS image sensor. Nevertheless, there is a sophisticated solution that uses the Camera Link interface, which is integrated into the pco.edge camera. It is a fact of nature that light, itself, has its own noise component called ***photon or shot noise***, which increases with light signal. In this approach, no compression is made in small signals, while for large signals a suitable compression is applied. Since the introduced compression error is always smaller than the photon noise induced error, it is not seen and a so called ***visual lossless compression*** has been performed.

It can be shown that this is possible without any significant loss of information. Therefore, the calculation for the pco.edge camera at full speed and full frame has to be re-written:

[2560 * 2160 (pixel in 1 frame) * 1.5 Byte (= 12bit dynamic)] * 100 [frames/s] = 0.829 GB/s

The Camera Link interface can transmit this in real-time. In the future, recently introduced machine vision interfaces including CoaXPress and Camera Link HS are capable of transmitting sCMOS image data without any compression. A network type interface, 10GigE, is similar with respect to hardware to Camera Link HS, but incorporates all of the known GigE advantages and disadvantages. Here, the usual protocols are not favorable for image data transmission, and any network traffic can dramatically reduce available transmission speed. ***The real-time data transmission into the computer allows for a variety of applications, since it is free from camera memory limitations.*** Image data can be stored directly in the computer's random access memory (RAM) up to more than 64 gigabyte. With an appropriate RAID system, the data can be stored directly to hard disks and there is no delay involved.

Option 2: Recording in the Camera

For high-speed imaging applications where data transfer rates are in the range of several GB/s it is accepted that the primary image memory (camRAM) must be located in the camera. Two examples of

such high-speed cameras are the pco.dimax with 36 GB of camRAM and the pco.dimax HD with 18 GB of camRAM memory. This allows for fast recording, but just up to the integrated memory limit. Before a second sequence can be recorded, one must endure the wait time until data is downloaded to computer storage. Therefore, this option can only be used for recording short sequences with enough time between each event to download the image data. This option is not necessary for the pco.edge as either with USB 3.0 or Camera Link interface, the image data will be recorded to the computer in real-time.

Memory Structure / Organization

As the memory is software-controlled in both options, it does not matter how the data is stored. The memory can be organized for ring buffer or FIFO recording, or for a specified number of images like a burst mode. The pco.edge camera enables all of these possibilities with the integrated dynamic link libraries and proprietary CamWare application software. This allows the customer to select the memory structure and organization that is optimized for the application at hand.

Recommendations

In the following you can find two exemplary systems for RAID and RAM storage options that have been successfully tested by pco for high performance ***and which we sell directly to our customers***. They only show a configuration example, for actual system configuration please call us directly.

RAID 0 SYSTEM	11x 2TB SATA 6 GB/s 16 GB DDR3 RAM Intel® Core™ i7-3820 processor 3.6 GHz GeForce GTS 640 2GB (NVIDIA CUDA) Windows 7 Professional 64 bit
RAM RECORDER	64 GB DDR3 RAM Intel® Core™ i7-3820 processor 3.6 GHz GeForce GTS 640 2GB (NVIDIA CUDA) Windows 7 Professional 64 bit

NOTE
Items are exemplary and subject to change. Please contact PCO for recommendation of current systems and sell of these systems. The use of normal consumer PCs is not recommended!

ASUS mainboards seem to fail generally during the HS-mode test and are not recommended.

Recommended minimum configuration (or better):

- CPU >= i7 2.5 GHz
- RAM >= 1066MHz, 8GB
- Mainboard ≥ Supermicro X9SRA (socket 2011)

A5 USB 3.0

A5.1 HARDWARE RECOMMENDATIONS

The pco USB 3.0 interface is based on the Cypress EZ-USB FX31 device and it is compatible to pco software such as CamWare and SDK. To run a pco USB 3.0 camera successfully the user should consider a number of important issues that are discussed in the following chapters.

Motherboard and Chipset Configuration

It is recommended to use a Motherboard with a state of the art USB 3.0 host controller for the onboard USB 3.0 ports. The latest generation of USB 3.0 xHCI host controllers manufactured by Intel, Renesas (NEC), Fresco, Via Labs, ASMedia and Texas Instruments Inc. (TI) are tested by Cypress Semiconductor Corporation. (see Cypress EZ-USB® FX3TM SDK Release Notes, Version 1.2.3, chapter 1.3). Currently pco recommends only motherboards with the following onboard xHCI host controllers:

- Renesas/NEC µPD720202 Host Controller
- Intel® USB 3.0 eXtensible Host Controller

If the motherboard does not have an onboard USB 3.0 port or the onboard USB 3.0 port does not work properly with a pco USB 3.0 camera, ***please use an independent PCIe USB 3.0 extension card***. In this case, pco recommends the following:

- DELOCK 89348 (U3-PCIE1XG202-10)
  PCIe 1x (µPD720202 host controller)
  (This board is sent with your pco.edge USB 3.0 camera system as standard)
- DELOCK 89325 (U3X4-PCIE4XE101)
  PCIe 4x (µPD720202 host controller)

USB 3.0 extension card with xHCI4 host controller

The following companies manufacture USB 3.0 xHCI host controller:

- Renesas Electronics America Inc. (earlier NEC),
- Texas Instrument Inc.,
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.,
- Intel Inc.,
- AMD Inc. and
- Etron Technology, Inc.

NOTE
To determine suitable manufacturers of the xHCI controller, please use the Windows Device Manager. For example, in Windows 7 drop down the USB Controller entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the properties dialog, click the ***details*** tab, and choose ***Vendor*** in the properties pull-down box.

NOTE
USB 3.0 interface cards with controllers from ***Etron*** Technology, Inc. have not yet been tested.

The following table gives an overview about tested and recommended system configurations or hardware components.

Component	Recommendation
Motherboard	There is no recommendation for a manufacturer. But if an onboard USB 3.0 port is used, the Renesas´s xHCI host controller µPD720202 is recommended.
USB 3.0 extension card	• DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller), • DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller)
PCIe Slot	A PCIe 4x, 8x or 16x slot is recommended.
USB 3.0 Cable	USB 3.0 cable included in the packaging of your pco USB 3.0 camera
USB 3.0 Hub	Not recommended
Operating System	Windows XP 32 Bit, Win7 32 / 64 Bit, Win8 32 / 64 Bit
Multiple pco USB 3.0 cameras connected to a PC	A separate DELOCK 89348 (U3-PCIE1XG202-10) extension card for each camera should be used to guaranty maximum data throughput of each camera.
FOL adapter	See **A5.5**

Recommended Software Components

The pco USB 3.0 driver supports Windows 7/8 (x86 or x64) and Windows XP x86 operating systems. Microsoft does not support USB 3.0 natively for Win 7 or older Windows versions. Therefore use the manufacturers' supplied xHCI host controller driver. By contrast, in Windows 8 Microsoft does provide a native generic xHCI Driver but pco recommends using the driver from the corresponding manufacturer of the xHCI host controller. Currently there are seven different vendors producing USB 3.0 host controllers:

- Renesas Electronics America Inc. (earlier NEC)
- Texas Instrument Inc.
- Intel Inc.
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.
- AMD Inc.
- Etron Technology, Inc.

Please make sure that the most recent driver from the manufacturer is installed before a pco USB 3.0 camera is connected to a USB 3.0 port of your computer. The appropriate driver for the USB 3.0 port could be loaded from the website of the manufacturer of the USB 3.0 host xHCI controller; or from the website of the USB 3.0 extension card vendor. The current driver of the extension card included in the packaging of your pco USB 3.0 camera is added to the ***pco.USB stick*** delivered with each pco.edge.

NOTE
To determine the driver currently in use for the xHCI controller, use the Windows Device Manager. For example in Win 7, drop down the USB-Controller entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the Properties dialog, click the driver tab and choose driver details

Before the pco.edge USB 3.0 camera is connected to the computer the pco USB 3.0 Driver has to be installed. (see **4.1**) Please visit the support section of our website to get the latest USB 3.0 camera driver.

A5.2 USB 3.0 FAQ

Can I use USB 2.0 PC components?
If the USB Port, the USB Cable, or the USB Hub does not support USB 3.0, a USB 3.0 PCO camera will not operate properly. The camera will be recognized in the Device Manager as a USB 2.0 device. Operation of the PCO camera using CamWare or one of the PCO SDK camera related functions will fail and the following message box will appear: “Please make sure your camera is connected to a USB 3.0 port. If your camera is connected to a USB 3.0 port, please read the application note APL_USB3_xxx.pdf”.

How to identify the manufacturer of the USB 3.0 host controller?
If a driver for the onboard USB3.0 port or an independent PCIe USB 3.0 interface card is already installed, open the Windows Device Manager. Then extend the ‘USB-Controller’ entry and find the USB 3.0 host controller of the specific USB 3.0 device in the sub-tree. Right click to open the Properties dialog and then click the ‘details’ tab which will allow you to identify the correct manufacturer of the USB 3.0 controller.

Why can’t the PCO USB 3.0 camera be opened with CamWare or the PCO SDK?
In case a PCO USB 3.0 camera is connected to your PC and the CamWare software starts in ***Demo Mode***; or, the Camera Open Function of the PCO SDK returns an error, the explanation could be: The PCO USB 3.0 driver is not installed to your system and the PCO USB 3.0 device is listed as “unknown device” in the Device Manager. If so, right click the ***unknown device*** to open the properties dialog and install the PCO USB 3.0 driver. The driver can be downloaded from our website at http://www.pco.de/drivers/. If the PCO USB 3.0 driver is properly installed, there will be a ***PCO cameras*** entry with a ‘pco.camera with USB 3.0’ device listed in the Device Manager. — Another issue could be that the USB 3.0 camera is not recognized by the OS and it does not appear in the Device Manger, meaning it is even not shown as ‘unknown device’. In this case please refer to Chapter 4.1 and follow the instructions provided.

Why was the PCO USB 3.0 camera not recognized by the OS?
There could be a problem with the USB 3.0 xHCI host controller of the Motherboard or with the extension card installed in the PC. Additionally, a bad USB 3.0 cable could be the problem.

How to increase the performance of the USB 3.0 data transfer?
To make sure the full data-throughput of the camera can be transferred to the PC’s RAM, it is recommended to use a PCIe 4x, 8x or 16x slot in the PC.
In the case of using Windows 8, poor performance could be caused by the Microsoft`s automatically installed generic xHCI USB 3.0 driver. In this case please load and install the driver of the manufacturer`s xHCI host controller.

If more than one PCO USB 3.0 camera is operated on a single PC, please note that extension cards have maximum bandwidths that with two or more cameras are being exceeded.
There exists a maximum bandwidth of an extension card, e.g. if the DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card is connected to a PCIe 16x slot of the PC the effective bandwidth is about 360 MB/s. If two PCO USB 3.0 cameras are connected to both ports of the extension card, the accumulated data throughput of both cameras cannot exceed this 360 MB/s maximum. In this case it would help to use a second DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card connected to a
second PCIe 16x slot of the PC for the second PCO USB 3.0 camera.

How many PCO USB 3.0 cameras can be connected to and operated with one PC? How many PCO USB 3.0 cameras are supported by the PCO USB 3.0 driver?
The PCO USB 3.0 driver supports up to eight cameras using one PC

The USB 3.0 PCO Driver Installer does not work.
The installer will return a warning that the current OS is not supported. The installer supports the 32-bit and 64-bit versions of Windows 7 and Windows 8.
If the installer file is executed and a no dialog window appears: Please try to install the driver manually using the Windows Device Manager. Contact our support team to get the driver files for manual installation.
The driver is correctly installed, but the USB 3.0 PCO camera does not appear in the Device Manager:
Make sure the PCO USB 3.0 camera is ready, the power switch is turned on, and the camera is connected to the PC.
Note that while installing the camera to the PC that during the USB 3.0 driver installation it could take a minute or more until the PCO USB 3.0 device recognized and is available for use.

A5.3 INSTALLATION OF THE USB 3.0 CARD

NOTE
Hardware Installation must be performed by a technician, because high voltages can occur on the device. Always pull the main plug before opening the device.

An external USB 3.0 Host Controller Card is enclosed to each pco.edge USB 3.0 camera.

Hardware Installation

First shut down your computer and install the USB 3.0 Host Controller.

Driver Installation Instructions

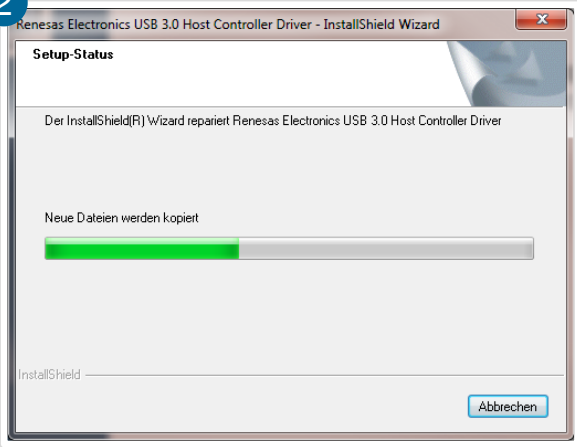
- Within the provided installation files ***USB_HBA***, open the folder U3X4-PCIE4XE101, U3X4-PCIE1XE101, U3-PCIE1XG202.
- Open the subfolder Driver and run RENESAS-USB3-Host-Driver-30230-setup.exe.
- If your current OS is Win7/8 and the User Account Control is enabled, a dialog could occur asking, if you wish to launch the setup: Accept with ***Yes***.

1. At first the installation is prepared.
2. Secondly the software components are copied.
3. Finally the installation is completed and the ***Delock USB 3.0 extension card*** can be used.

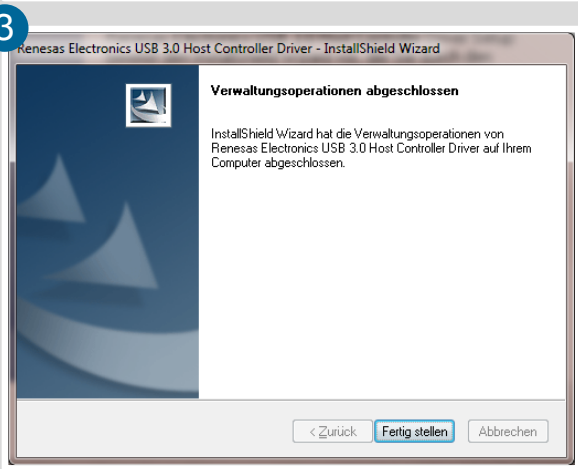
1

Renesas Electronics USB 3.0 Host Controller Driver - InstallShield Wizard
Installation wird vorbereitet...
Renesas Electronics USB 3.0 Host Controller Driver Setup bereitet den InstallShield Wizard vor, der Sie durch den Setup-Vorgang leiten wird. Bitte warten.
Installation wird vorbereitet...
Abbrechen

2


Renesas Electronics USB 3.0 Host Controller Driver - InstallShield Wizard
Setup-Status
Der InstallShield(R) Wizard repariert Renesas Electronics USB 3.0 Host Controller Driver
Neue Dateien werden kopiert
InstallShield
Abbrechen

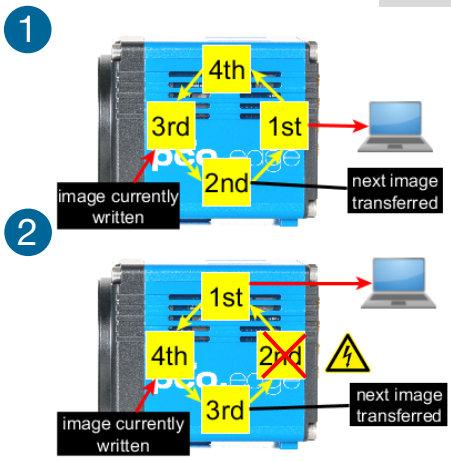
3


Renesas Electronics USB 3.0 Host Controller Driver - InstallShield Wizard
Verwaltungsoperationen abgeschlossen
InstallShield Wizard hat die Verwaltungsoperationen von Renesas Electronics USB 3.0 Host Controller Driver auf Ihrem Computer abgeschlossen.
< Zurück
Fertig stellen
Abbrechen

A5.4 RING BUFFER AND FIFO

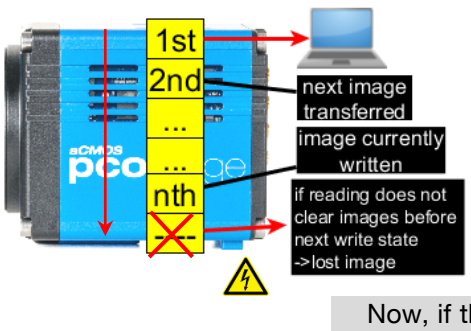
Compared to the pco.edge cameras with Camera Link interface, the pco.edge with USB 3.0 interface has a small ***internal buffer memory integrated***. Each recorded and read out image is directly transferred to this internal buffer and subsequently the image is transmitted to the computer, where it is either stored into the RAM or onto the hard disk drive. There are two transfer modes available: Ring Buffer and FIFO buffer which can be accessed via SDK function: ***PCO_SetStorageMode*** (see SDK manual).
From user perspective the main difference between both modes occurs, if for some reasons the USB 3.0 interface behaves ***slower*** than its usual speed. In this case the Ring Buffer delivers faster the most recent image than the FIFO Buffer mode, which can be helpful for example if the image should be focused.

Ring Buffer (in camera memory–standard mode)



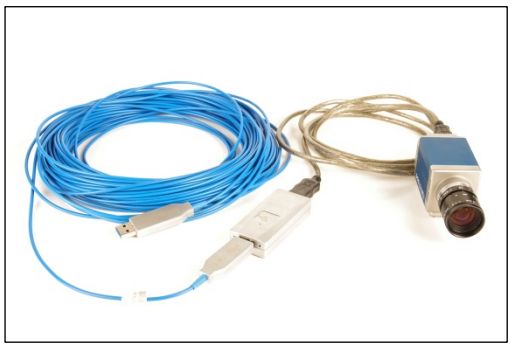
As described the read out and recorded image is directly transferred into the internal buffer memory. Subsequently the next image is stored to the next free space. For the transmission from the camera to the computer ***always the most recent image*** is used, which works fine in case the computer does not do anything else than transfer images to its internal storage memory (RAM). 1
Now, if the transmission speed of the computer system is interrupted by e.g. software, it can happen that images get lost, because in Ring Buffer mode the most recent image has to be transmitted to the PC. In case of a delay in transmission, the image in the memory, which waits for transmission ***will lose its status as most recent image*** to the next image, and will be disregarded for transmission. Hence this image will be ***irretrievably lost***. 2 Because Ring Buffer always transmits the most recent image and therefore the most real-time transmission, it is the ideal mode for e.g. adjustment of focus.

FIFO Buffer (in camera memory)



Like above the read out and the recorded image is directly transferred into the internal buffer memory. Subseqently the next image is stored to the next free space in memory. If all the memory space is occupied the ***camera stops storing***. In FIFO buffer mode like name stated, FIFO = first-in first-out, the first stored image is read-out from the memory first and subsequently transmitted to the computer. This as well works fine in case the computer does not do anything else than transfer of images to its internal storage memory.
Now, if the transmission speed of the computer system is interrupted by e.g. software, then still the first stored image is readout, and then the next image is read out and transmitted. However there could be a delay time (but need not). If now the slowdown causes the FIFO buffer to be completely filled, then the camera stops storing images and the next image will ***irretrievably lost*** as well, but in this mode it is ***lost before storing.*** This mode is ideal for users who need maximum transmission security; an image loss is very unlikely.

A5.5 USB 2.0/3.0 FOL EXTENDER



The ***Adnaco-SU1*** is a FOL Extender for USB 1.1./2.0/3.0 devices. It contains two components: the ***Adnaco-UT1*** (USB Converter) with power supply and the ***Adnaco-UF1*** (active USB 3.0 FOL cable (integrated electrical optical converter with length of 10, 30, 50 and 100m).

The UT1 transmits signals from USB 1.1/2.0/3.0 to USB 3.0 and has two Type-A USB connectors named ***Host*** and ***Device*** and a 5.0V power supply device. The ***Host connector*** has to be linked with the ***UF1 USB 3.0 FOL cable*** and this cable has to be connected directly to the computer.

The ***Device connector*** has to be connected with the pco.edge usb camera (example picture shows pco.pixelfly usb camera).

If you ***confuse*** the connections, the camera will ***not*** be identified by your computer. There shouldn't be any damages to your devices if you confuse the connections.

The UF1 is a pure USB 3.0 cable and is built up symmetrically and therefore it is not possible to confuse the connections or to connect the pco.edge (which has a USB Type-B connector) with this cable.

This system only works at a computer with USB 3.0, your camera will not be identified if you connect it to a USB 2.0 connector.

The Adnaco-SU1 is an optical insulator and also gives you the opportunity to physically extend the transmission path between camera and computer.

Performance

If you use a USB 2.0 device at the Adnacu SU-1 a maximum data transfer rate of 24.5 Mbytes/s will be reached.

Cable length	USB 3.0*1	USB 2.0*2
USB Configuration Without SU-1	357 Mbytes/s	40.1 Mbytes/s
SU-1 10m cable	352 Mbytes/s	24.5 Mbytes/s
SU-1 100m cable	330 Mbytes/s	23.4 Mbytes/s

*1: e.g. pco.edge *2: e.g. pco.pixelfly usb

A6 BINNING IN CMOS SENSORS

Binning describes the summation of single pixels to form larger pixels and thereby improve the signal-to-noise ratio (SNR).

Binning in CCD image sensors

The term binning comes from scientific CCD image sensors. The prominent feature of charge-coupled-devices (CCD) is the lossless transport or shifting of charge packages until an amplifier circuit converts them into a voltage at the output, where the main readout noise contribution occurs. If charge packages from two or more pixels are added before they are read out (past the output amplifier) because of very low light signals; this process is called binning. Since the signal is increased before it is read out, and the image sensor's readout characteristics remain unchanged, binning improves the SNR, and the image sensor's resolution is reduced. The lossless transport feature of CCD image sensors makes binning possible.

Binning in CMOS image sensors

In general, binning is not possible in CMOS image sensors because voltages are processed and no charges are transported. In each pixel, the light generated charges are converted into voltages with the readout noise contribution of these amplifiers. Therefore, as opposed to CCD image sensors, if these voltages were combined, the readout noise would also be combined, which would not have the same positive effect on the SNR.

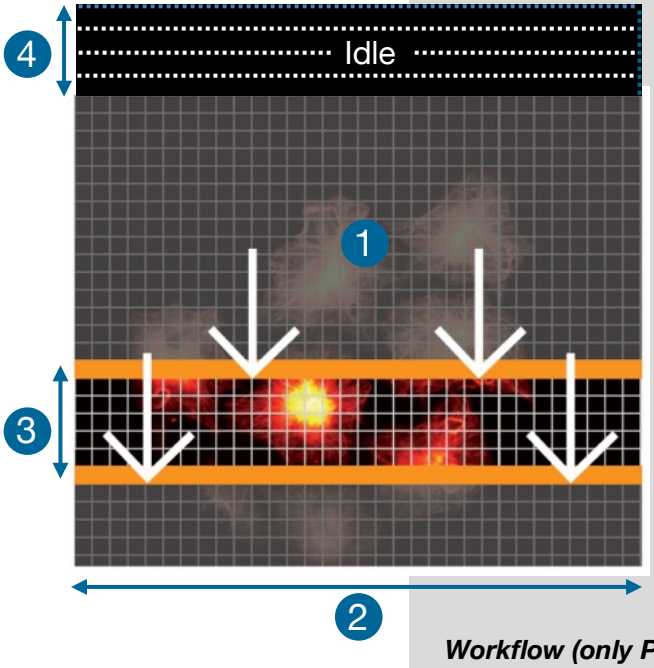
Nevertheless, such a summation or even an averaging would be beneficial for the SNR, but with a smaller impact compared to CCD image sensors. Since such ***CMOS binning*** cannot be done within the image sensor, it either has to be done in the camera or in the computer.

NOTE
The current default binning mode is accumulation. Averaging is not available within CamWare.

CMOS binning 1 – accumulation: Pixel values can accumulate, causing an effective dynamic reduction or larger number formats, because the result might exceed the original format -- two times maximum 8 bit values will result in a 9 bit value. This will not be a problem if 12 bit values are accumulated and transported as 16 bit images. However, in the case of scientific CMOS, if 16 bit values are transmitted in 16 bit images, only two times 15 bit maximum values are allowed. The signal of the binned pixels will be accumulated, due to the properties of readout noise; the increase of the noise itself will only be as big as the square root of the number of binned pixels. The SNR will improve and in addition, a reduction of the stored image data is achieved.

CMOS binning 2 – averaging: Pixel values can be averaged, which has the same effect on the SNR as accumulation due to the properties of noise. This would keep the image output format the same and would reduce the amount of image data that can be stored. When this type of ***CMOS binning*** is processed in the camera it is called ***hardware binning***. This should not be confused with real binning in CCD image sensors, because the ***hardware*** that processes this binning is not much different from the ***hardware*** in computer processing. Therefore, the term ***hardware binning*** may be misleading.

A7 LIGHTSHEET SCANNING MODE



The pco.edge ***Lightsheet scanning mode*** is a special mode for lightsheet microscopy and only available for ***Camera Link*** versions via SDK (not in CamWare).

It is based on Rolling Shutter mode with ***slow scan*** rate (95.3MHz) and uses the readout mode ***single top down*** (***Mode E*** see **7.4**)1

Standard line time value is ***40 µs*** 2 and it can be set from camera specific line time (see p.**6**) up to 100 ms. An ***exposure area*** (between the orange bars, e.g. ***five lines*** 3) can be user defined. It is possible for the user to select the number of lines and the exposure time per line.

This user-defined capability makes it possible to synchronize the pco.edge cameras with a lightsheet microscope that requires this method of camera exposure timing

Workflow (only PCO SDK)

- Set ***Rolling Shutter*** mode
- Set pixel rate to ***slow scan***
- Set readout format ***E*** 1
- Set ***line timing on*** and the appropriate line time 2
- Set ***number of exposure lines*** 3
- Set ***number of delay lines*** 4
- Trigger mode and acquire mode and hwio settings are free to select by the user

SDK settings: (see SDK manual)

SC2_SDK_FUNC int WINAPI PCO_SetCmosLineTiming	wParameter 1 wTimeBase (e.g. **µs** 2) dwLineTime (e.g. **40** 2)
SC2_SDK_FUNC int WINAPI PCO_SetCmosLineExposureDelay	dwExposureLines (e.g. **5** 3) dwDelayLines (e.g. **4** 4)

A8 IMAGE FILE FORMATS

There are different file formats available for saving camera images with CamWare.

b16
The b16 16 bit format is similar to the bmp format. However, 16 bit pixel values are used instead of 8 bit pixel values.

The file format consists either of a Basic Header (6 Long-parameter) or of an Extended Header (32 Long-parameter), the latter of which is optionally for additional information. There might follow a variable comment field (ASCII code). Finally, there is the actual data set that is saved linearly (as in the case of BMP files).

With the exception of the first value, all parameters are Long Integers (4 Byte). The first 6 parameters must always exist. The rest of the parameters, as well as the comment field, are optional.

	Parameter	Function
1	pco-	the first 4 byte are the characters pco-
2	file size	file size in byte
3	header length	header size + comment filed in byte
4	image width	image width in pixel
5	image height	image height in pixel
6	extended header	-1 (true), extended header follows
7	color mode	0 = black/with camera, 1 = color camera
8	b/w min	black/white LUT-setting, minimum value
9	b/w max	black/white LUT-setting, maximum value
10	b/w linlog	black/white LUT-setting, 0 = linear, 1 = logarithmic
11	red min	red LUT-setting, minimum value
12	red max	red LUT-setting, maximum value
13	green min	green LUT-setting, minimum value
14	green max	green LUT-setting, maximum value
15	blue min	blue LUT-setting, minimum value
16	blue max	blue LUT-setting, maximum value
17	color linlog	color LUT-setting, 0 = linear, 1 = logarithmic
18 … 266	internal use	
Comment file in ASCII characters with variable length of 0…XX. The length of the comment filed must be documented in the header length field.		
		16 bit pixel data
line 1, pixel 1		value of the first pixel
line 1, pixel 2		value of the second pixel
…		…

We recommend that all images should be saved first in the b16 or TIFF format. The advantage is to have the b16 or tiff images available all the time. You will always have the maximum 16 bit information. Please note that not all image analysis programs can accommodate 16 bit data. The 8 bit format saves only the information displayed on the monitor screen. The 16 bit information will be lost and cannot be displayed later.

pcoraw
This 16 bit pco file format is based on the new BigTIFF format, thus allowing for file size > 4GB. A new pco proprietary compression scheme is added in case it is necessary.

Standard File Formats

TIFF
Tag Image File Format, version 6.0 and lower. There is a 16bit monochrome and color image format.

BMP
Windows Bitmap Format, b/w or color 8 bit format-images, which have been saved in BMP format can be loaded later only as 8 bit images, i.e. part of the original information (16 bit) is lost.

FTS
Flexible Image Transport System, Version 3.1. There is a 16 bit image format. The NASA/Science Office of Standards and Technology (NOST) has defined this format. Some programs use the FIT extension for this format.

ASCII
16 bit format, some mathematical programs prefer ASCII data.

JPG
JPEG (named after the Joint Photographic Experts Group who created the standard) is a commonly used method of lossy compression for photographic images. The degree of compression can be adjusted, allowing a selectable tradeoff between storage size and image quality.

JP2
JPEG 2000 is a wavelet-based image compression standard and coding system. It was created by the Joint Photographic Experts Group committee in the year 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created 1992).

AVI
Audio Video Interleave is a multimedia container format introduced by Microsoft in November 1992 as part of its Video for Windows technology.

MPG
MPEG-1, similar to JPEG, is a standard for lossy compression of video and audio developed by the Moving Picture Experts Group (MPEG).

WMV
Windows Media Video (WMV) is a compressed video compression format for several proprietary codecs developed by Microsoft. The original video format, known as WMV, was originally designed for Internet streaming applications, as a competitor to RealVideo.

A9 CUSTOMER SERVICE

A9.1 SERVICE AND MAINTENANCE

Service

The camera is designed to operate with no need of special adjustments or periodic inspections.

Maintenance

Unplug the camera from any power supply before cleaning it.

Use a soft, dry cloth for cleaning the camera.
Do not use liquid cleaners or sprays.

The lens is best cleaned with pressurized air or with liquid cleaners such as pure alcohol or with special optical cleaners that are available at high quality photo stores.

Never use aggressive cleaning liquids such as gasoline, acetone, spirits or nitro cleanser.

Every time the input window is cleaned, there is the possibility of surface damage. Do not clean the input window unless it is absolutely necessary. Be careful and avoid scratches and damage to the input window surface.

Use a cotton swab dipped in pure alcohol or optical cleaning liquid and wipe only on the glass surface. Do not get any cleaning liquid on the metallic parts such as the lens thread, because tiny detached particles may scratch the surface.

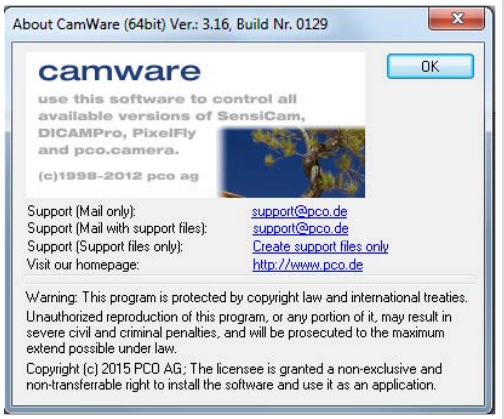
Always store the camera with the protective cap or with a lens mounted to avoid dust and dirt on the input window!

Camera Disposal

The camera includes electronic devices, which can contain materials harmful to the environment. If the camera is to be discarded, please dispose of it in an environmentally responsible manner and use recycling facilities, where available.

A9.2 TROUBLE SHOOTING

If you have a question, which is not adequately addressed in this manual, please contact ***PCO*** or your ***local dealer.***


About CamWare (64bit) Ver.: 3.16, Build Nr. 0129
camware
use this software to control all available versions of SensiCam, DICAMPro, PixelFly and pco.camera.
(c)1998-2012 pco ag
OK
Support (Mail only): support@pco.de
Support (Mail with support files): support@pco.de
Support (Support files only): Create support files only
Visit our homepage: http://www.pco.de
Warning: This program is protected by copyright law and international treaties. Unauthorized reproduction of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extend possible under law.
Copyright (c) 2015 PCO AG; The licensee is granted a non-exclusive and non-transferrable right to install the software and use it as an application.

To speed your request, we need the following information:

- Short description of the problem
- Description of your application
- Camera settings
- Type and version of camera software being used
- Camera serial number
- Operating system (PC)
- Processor type (PC)
- Memory
- Graphic card
- Graphic card setup

Please use the email options under the Help menu (see **7.8**)

How to create a logfile:

- Enable log files: ***File Menu*** → Options → MISC (see **7.3**.)
- Reboot your pco.edge
- Repeat the workflow which produces the faults.
- Open the ***About CamWare*** window (***Menu ? → About***) and click at the support links to send an email directly to PCO-Support (see **7.8**)
- Or visit our website: http://www.pco.de/support/

Repair

Before sending the camera for repair, first contact your local dealer or PCO respectively.

When shipping the camera for repair, be certain to carefully pack the camera with proper shipping materials. If possible use the original packaging. Use the protection cap to protect the camera on the lens thread.

Firmware, Software and Driver Update

You will find all necessary software and drivers on the accompanying USB storage device.

For the latest versions please check our website:
http://www.pco.de/support/supportProducts/scmos-cameras/

ABOUT PCO

In 1987, PCO was founded with the objective to develop and to produce specialized, fast and sensitive video camera systems, mainly for scientific applications. Meanwhile the product range of PCO cameras covers digital camera systems with high dynamic range, high resolution, high-speed and low noise, which are sold in the scientific and industrial market all over the world.

Currently PCO is one of the leading manufacturers of scientific cameras. Worldwide representatives, together with our own sales department and technical support assure that we keep in touch with our customers and their needs. The actual wide range of specialized camera systems is the result of technical challenge and product specific know-how. A design according to advanced techniques, a high standard of production and strict quality controls guarantee a reliable operation of the cameras. Our own developments in conjunction with an excellent contact to leading manufacturers of image sensors ensure our access to state-of-the-art CCD- and CMOS-technology for our cameras.

Since 2001, PCO is located in its own facility building in Kelheim at the shore of the beautiful and international river Danube. Here in the county Bavaria, which is well known for its excellent support and conditions for high technology companies, we share the benefits of the simple access to high performance products and services in the surrounding area.

Kelheim itself is a historical town, first documented in 866. The small city is founded at the confluence of the Danube and the Altmühl, which has been converted into the Rhine-Main-Danube bypass channel for water transport. Located in Danube-valley, it is the heart of a beautiful river and forest covered lime plateau landscape. It´s landmark, the Hall of Liberation, was built by Ludwig I. in 1863 on the Mount Michael and is visible from all over the city and valley. The beautiful Danube-Gorge, which is protected as natural monument since 1840, is located between Kelheim and the famous abbey Weltenburg.

pco.